March 1913. Chemical Series. Vol. II, No. 6.

Memoirs of the Department of Agriculture in India

THE DATE SUGAR INDUSTRY IN BENGAL

AN INVESTIGATION INTO ITS CHEMISTRY AND AGRICULTURE

BY

HAROLD E. ANNETT, B.SC. (London), F.C.S., M.S.E.A.C

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ASSISTED BY

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Assistants to the Imperial Agricultural Chemist

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PUBLISHED FOR

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BY

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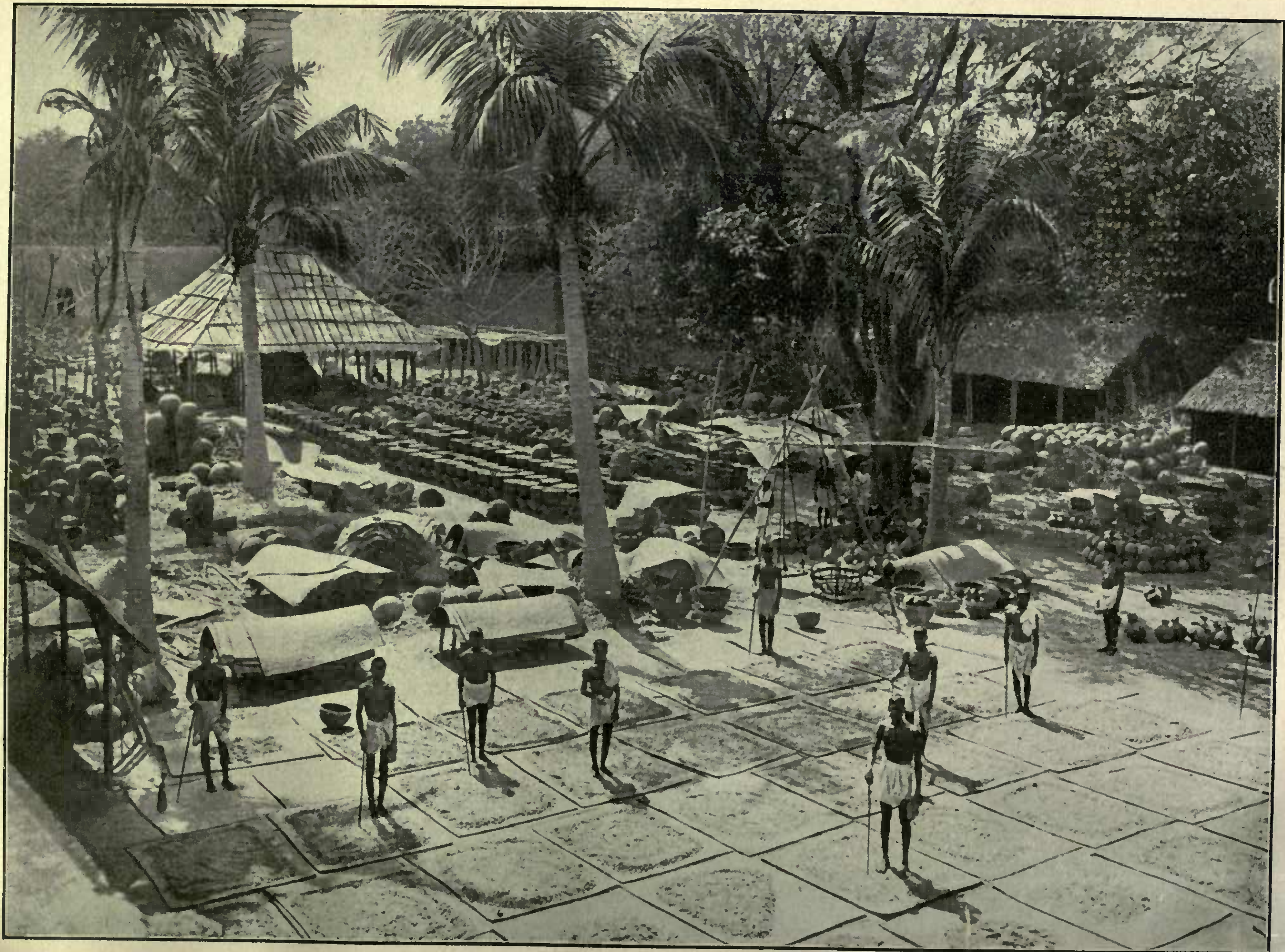

Native Sugar Refinery.—General View. In foreground is seen refined sugar spread on bamboo mats. The coolies are crushing the lumps with their feet. In the background is the place where molasses is reboiled to gur (see Plate VIII). In the middle distance are the baskets containing gur, from which molasses is running off by gravity into pans beneath.

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PREFACE.

In the present state of the Indian sugar industry it is desirable to investigate all sources of sugar production in this country. That the Palm sugar industry is of no small importance the following memoir will shew. It is proposed, if circumstances permit, to thoroughly examine the state of the industry as it exists in different parts of the country. In this memoir a beginning has been made in Bengal where the Wild Date Palm (Phœnix sylvestris) is such an important sugar producer. It is hoped later to carry out similar work with other sugar producing palms in Madras.

My thanks are due to Dr. J. W. Leather, Imperial Agricultural Chemist, who first called my attention to the industry. I have much pleasure in acknowledging the great help given to us in our work by Messrs. E. G. and H. C. Macleod of Kotechandpur, Jessore. Their intimate knowledge of the sugar trade and of the people of Jessore has been invaluable to us. Mr. E. G. Macleod kindly provided us with accommodation for our camp laboratory and without his aid much of our work would have been impracticable.

H. E. ANNETT.

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PART I.

INTRODUCTION.

It has been remarked by a well-known authority[1] that "we shall never obtain a definite knowledge of the Indian sugar question until palm sugar has not only received more careful consideration but has been made the subject of independent investigation."

It may surprise some to learn how large this palm sugar industry is.

The most recent figures relating to it have been put on record by Mr. Noel-Paton,[2] Director-General of Commercial Intelligence. He puts the total annual yield of palm sugar in India at roughly 480,000 tons. Of this amount it is stated that 125,300 tons are annually produced in Bengal, including Eastern Bengal and Assam. It is presumed that these figures relate to raw sugar, *i.e.*, jaggery or gur. The total output of all sugar in India annually, reckoned as gur, may be put at 3,000,000 tons. Thus it would seem

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[1] Watt's Dictionary of Econ. Prodts., Vol. VI, Part II, page 310.

[2] Notes on Sugar in India, 1911.

that roughly 17 per cent. of India's sugar is produced from palms, but the author thinks that 10 per cent. would be a nearer estimate.

The amount of sugar produced annually throughout the world from various sources, is according to August von Wachtel[1]

From cane	9 000,000 tons.
From beet	8,000,000 tons
From sugar palm (P. sylvestris)	150,000 tons.
From maple	500,000 tons.

The author assumes that these figures relate to refined sugar.

A careful enquiry[2] by the Government of India in 1889 shewed that 168,262 acres were under palms connected with sugar supply. If we take two and a third tons of gur, a safe figure, as the yield of sugar per acre we should get a total yield approaching that of Mr. Noel-Paton's estimate.

Palm-gur and its products are largely consumed in the districts in which they are produced and it is very difficult to get an idea of the amount of gur exported to other districts or of the amount which is refined to high grade sugars.

According to Aubert[3] the palm-sugar producing districts of Upper Burma export annually about 36,500 tons of sugar, presumably as gur.

The Indian Agriculturist[4] in 1900 stated that the annual value of palm jaggery bought by a single Madras firm for refining was more than 15 lakhs. At Rs. 4 per maund this would be roughly 16,000 tons.

In the Imperial Gazetteer[5] we find it stated that in Jessore district alone there were in 1900-1 117 native sugar refineries with an outturn of 235,000 maunds valued at 15·15 lakhs. This is 6,500 tons and would require 16,250 tons of gur for its production. Most of this sugar refined in Jessore goes to Calcutta and is largely used for the preparation of native sweetmeats.

---

[1] Jour. Ind. & Eng. Chemistry, May 1911, Development of the Sugar Industry.

[2] Resolution, dated 20th March 1889.

[3] Agric. Jour. of India, Octr., 1911, page 375.

[4] Vol. XXV, 1900, page 116.

[5] Vol. XIV, page 96.

Mr. Noel-Paton in his notes on sugar previously referred to puts the annual output of refined commercial palm-sugar in India at 64,230 tons valued at Rs. 1,31,02,900 or nearly £ 1,000,000 sterling. Similar figures which he gives for cane sugar are 366,600 tons valued at 7,47,94,600 rupees or £ 5,000,000 sterling.

PART II.

HISTORICAL AND STATISTICS OF PRODUCTION.

Having shown how important an industry the production of palm sugar is, it may be of interest to give a short account of the history of its growth in Bengal. In this chapter the writer does not propose to include other palm sugar producing tracts in India because he has no knowledge of them.

Almost all the palm sugar produced in Bengal is made from the wild date (Phœnix sylvestris). In certain parts of the Sunderbunds a small amount is produced from the palmyra palm (Borassus flabelliformis).

In Jessore, the most important of the sugar producing districts, the industry is an old one. The Collector of Jessore in 1788 enumerated as one of the losses caused by the cyclone of 1787 the injury to the date trees and the weakening of the sugar produce.[1] Later on, in 1792, he wrote that "date sugar is largely manufactured and exported," and in a statistical table prepared in 1791 we find it recorded that 20,000 maunds was the annual produce of the sugar cultivation and that about half of this was exported to Calcutta. At that time, however, there was a considerable production of cane sugar as well.

Production[2] of date sugar greatly increased in Bengal from 1830 onwards, though not to the extent that it would doubtless have done, had it not been checked by the violent fluctuation in its value, which will be referred to presently. The following brief sketch of its progress is necessarily imperfect from the great want of reliable statistics on which to frame it. Previous to the first inroads on the

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1 See report on the district of Jessore by Westland, 1874.

2 The date tree, a prize essay on the manufacture of its sugar, S. H. Robinson, 1858.

East India Company's trade monopoly in 1813 it was hardly known as an article of export. It was manufactured only to meet the wants of native consumers in and around the few places of its production, principally in Jessore and Faridpur districts. It was occasionally transported to the principal markets of the adjacent districts, and especially to Murshidabad and Dacca in the days of their prosperity, when, previous to the British rule, they were the centres of the trade and wealth of Lower Bengal.

Imports of East India sugar into Great Britain gradually increased from 6,282 tons in 1816 to 13,453 tons in 1823. Throughout this period onward till 1837 all sugars from India were loaded with an additional duty of 10 shillings per cent. beyond the rate charged on West Indian sugars. The trade fell off and exports from Bengal to Great Britain from 1830-6 averaged below 6,000 tons per annum. There are no data to show what proportion of exports consisted of date sugar, but these figures show that the production of East Indian sugar met with little encouragement.

Date sugar, however, has always been a favourite luxury with the native population. Its production is preferred in its own districts to that of cane sugar, owing to the more expensive and precarious cultivation of the sugar-cane.

In 1833, Robinson[1] estimated the total production of date sugar at 90,000 maunds, and in 1837 at 100,000. These figures relate to refined sugar, and would be equivalent to about 225,000 maunds, or 8,000 tons, and 250,000 maunds, or 9,000 tons of gur respectively. In 1837 the duties on sugar imported from the East and West Indies were equalised. Exports from Calcutta to Great Britain swelled from 13,403 tons in 1836-7 to 63,084 tons in 1840-41. Trade then became steady and onward till 1847-48, the average exports were 60,000 tons. Here again it is difficult to say what was the proportion of date sugar, but in 1848 the total date crop per annum in Bengal was estimated at 15,000 tons of refined sugar

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1 Prize essay, page 7.

or 38,000 tons of gur. Two-thirds of this was estimated by Robinson to have been exported from Calcutta and the rest consumed locally. Watt[1] also quotes 38,000 tons as the production of date sugar in Bengal for 1847-8. Thus the production had quadrupled in ten years. High prices ruled throughout this decade.

The first European refinery in Bengal was established in 1829 in the Burdwan district, but owing to the differential duties on sugars exported to Great Britain its operations were restricted to very narrow limits until 1837-38. Encouraged by the equalisation of the duties, competitors then appeared, principally in the vicinity of Calcutta. Their proprietors were not slow to discover the good qualities of date sugar as raw material for refining and they drew largely from the Jessore and Faridpur markets. Supported as they were by English capital they contributed in no small degree to stimulate the cultivation.

Under these encouraging circumstances it might have been expected that date sugar production would have increased more than the estimate had made it in 1848. Undoubtedly during the forties many new plantations were set out, but for the first five years no produce is obtained and the tree comes to full bearing only in its eighth year of growth. We next come to the first great check experienced by the cultivators.

The principles of free trade were rapidly gaining ascendancy in Great Britain and in 1846 Parliament enacted[2] in defiance of and in contradiction to all its previous tendencies for half a century, that in the article of sugar only, slave labour and slave trade should be encouraged. Further that by a scale of duties gradually equalised, the sugar produce of all the world by the end of seven years from that time should be admitted to British consumption on equal terms. As a consequence the English markets were inundated with supplies of foreign sugars and towards the end of 1847 they and our sugar colonies suffered a panic. Many a West India proprietor was

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[1] See Dict. of Econ. Prodts., Vol. VI, Part II, page 115.
[2] Robinson Prize Essay, 1858, page 9.

ruined, while in Bengal all sugar fell in value below the cost of production, and large sums of British capital invested in sugar refineries there were annihilated. In 1851 a second glut and panic occurred in the markets of Great Britain and in January and February 1852 sugars in Calcutta were nearly unsaleable. The date crop would have been a large one but for this discouragement and the date cultivators abandoned the trees.

The business of date tree cultivation being with two or three isolated exceptions entirely carried out by the impoverished ryot, during these two periods of depression at least, all planting of young trees was suspended and all care of young plantations neglected, but it is probable the checks were lasting in their effects, and that the planting since 1848 did not continue in the same increasing ratio as before that year. Still productions continued to increase and in 1857-58 the annual production of dry sugar was estimated at 35,000 tons equal to 88,000 tons of gur, of which two-thirds were exported to Calcutta. Had the cultivation not received the checks mentioned, there seems no doubt the produce would have again quadrupled during the eight years 1850-58 as it did from 1838-46.

Summary of Progress of Cultivation.

	Refined sugar.	Gur equivalent.
	Tons.	Tons.
From 1792 to 1813 it averaged	550	1,370
In 1833 it was	3,300	8,200
„ 1837 „	3,700	9,200
„ 1848 „	15,000	38,000
From 1854 to 1858 it averaged	35,000	88,000

So great and steady an increase in cultivation, in spite of partial checks, is sufficient evidence of its value as a remunerative branch of industry. The slave emancipation measures gradually decreased the supplies of sugar from the West Indies and this partly accounts for the rapid rise in date sugar production in the middle of the last century.

In 1849, 10,000 tons or 1/5 of the whole annual quantity exported from India to England was date sugar.[1]

Between 1858 and 1876 the only figures relating to the production of date sugar which we have been able to find, refer only to the Jhenidah and Magurah sub-divisions of Jessore. These are quite sufficient to show that during that period the industry was growing with great rapidity. The table[2] shows the number of native refineries at work in these sub-divisions during the years 1861-73 with their outturn in refined sugar in tons.

Number of native refineries at work.	Year.	Outturn of sugar.
		Tons.
—	1861-2	124
16	1862-3	756
15	1863-4	295
19	1864-5	907
24	1865-6	1,111
36	1866-7	1,381
47	1867-8	1,852
55	1868-9	1,581
67	1869-70	1,951
75	1870-1	2,195
85	1871-2	2,506
113	1872-3	3,805

In 1873, the Jhenidah and Magurah sub-divisions of Jessore alone produced 16,000 tons of gur of which 8,000 tons were refined by native methods.[3]

The reports on the internal trade of Bengal, issued in 1876-77 and 1881-82, give figures showing how rapidly the industry was growing at that time. The table shows the exports of sugar from various districts in 1875-76 and 1876-77 in maunds.

	Refined. 1876-7.	Unrefined.	
		1875 6.	1876-7.
Jessore	142,300	775,000	667,800
Nuddea	36,500	200,000	305,400
24-Parganas	150,600	275,000	274,700

[1] Robinson's Prize Essay, page 191.

[2] Report on the Agric. Statistics of Jessore, Jhenidah and Magurah sub-divisions, 1872-73, by Babu Ramshunker Sen, Calcutta, 1873.

[3] Loc. cit.

Assuming that 40 per cent. is the yield of refined sugar from gur, then in 1876-7, 80,000 tons of date sugar reckoned as gur was exported from the above three districts alone.

The corresponding report issued for 1881-2 remarked that—"raw date sugar is one of the most important manufactures of Nuddea district and it is said that there are no less than 60 sugar manufactories in Chooadanga alone. The sugar industry in Jessore is also said to be decidedly on the increase. The total production of raw sugar in Jessore is reported to be 400,000 maunds (equal to 1,000,000 maunds of gur or 37,000 tons) worth Rs. 16,00,000. There is only one establishment in Jessore for the manufacture of sugar after the European method, at Tahirpur, but no statistics of its outturn have been obtained."

In 1888[1] Bengal (presumably including Eastern Bengal) is again said to have produced 743,000 maunds of date gur. This is only about 27,000 tons. The figures seem to show that the sugar traffic had considerably detracted by this time but Watt admits they may have been much underestimated.

Turning to more recent figures, in the following table is set out the approximate amount of gur produced from the juice of the date palm in Bengal, from 1902-3 to 1910-11. For these figures we are indebted to the Director of Agriculture, Bengal. They are based on the estimates of the district officers.

	Year.	Gur produced from date palm.
		Tons.
Before the partition of Bengal	1902–3	143,892
Before the partition of Bengal	1903–4	114,616
Before the partition of Bengal	1904–5	162,858
	1905–6	77,838
	1906–7	77,984
	1907–8	72,362
	1908–9	66,572
	1909–10	67,518
	1910–11	66,900
	1911–12	66,930

[1] Statistics of sugar plants and sugar in 1888. Department of Agriculture, Bengal.

In Bengal proper about 15 per cent. of the total outturn of gur is said to be date gur.

In general it appears that the industry began to assume important proportions from about the middle of last century. During the last twenty years or so it appears to have been declining. It seems probable that the causes for this decline are the same as those which are causing a similar decline in the production of cane sugar in India.

A warning might here be added against placing too great reliance on the accuracy of the figures showing the amount of gur produced from the date palm annually.

It seems to the author that estimates of production of palm sugar are best based on the number of trees. The Collector of Jessore has very kindly had counted for me the total number of trees in use for sugar production in his district. The counting has been done during the current year (1912) and pains were taken to get as accurate results as possible. The detailed results are here set out as they may be of use for future record.

District.	Sub-division.	Thana.	Number of trees.
Jessore	Sadar ..	Kotwali	780,440
		Keshabpur	489,718
		Manirampur	808,058
		Jhikargacha	370,494
		Bagherpara	325,558
		Chaugachha	208,719
		Nowapara	173,051
		Total ..	3,156,038
	Bongaon ..	Bongaon	253,896
		Gaighatha	95,501
		Moheshpur	468,924
		Sarsa	218,146
		Total ..	1,036,447
	Jhenidah ..	Total ..	1,640,728
	Magurah ..	Magurah	108,608
		Mahamadpur	83,465
		Salikha	127,872
		Sripur	71,115
		Total ..	391,050

District.	Sub-division.	Thana.	Number of tress.
Jessore		Narail	139,107
		Abhayanagore	137,333
	Narail ..	Kalia	152,273
		Lohagorah	100,834
		Alfadanga	30,909
		Total ..	560,456
		Grand Total ..	5,143,991

Thus in Jessore district alone there are over five million date palms yielding sugar. This total includes old and young trees, as well as those in full bearing.

As we shall see later (p. 351) $21\frac{1}{4}$ lbs. of gur may be looked upon as an average annual yield per tree. Hence the total annual production of date palm gur in Jessore district alone must be somewhere about 50,000 tons. This fairly well corresponds to the estimate of 61,500 tons made by N. N. Banerjee.[1]

I have been able to find some old figures[2] shewing the number of date trees used for sugar making, in each of the districts of Bengal in 1848. I am indebted to Mr. S. G. Hart, Director of Agriculture, Eastern Bengal and Assam, for corresponding figures for certain of the same districts in 1911. The figures are given below for comparison.

Districts.	Number of date palms.	
	1848.	1911.
Dacca	5,000	250,000
Mymensingh	....	600
Faridpur[3]	1,501,000	805,014
Bakarganj[3]	50,000	637,550
Chittagong	100,000	74,000
Tipperah	....	88,000
Rangpur	20	3,722
Bogra	....	200
Pabna	14,000	49,100
Total ..	1,670,020	1,908,186

[1] N. N. Banerjee. The Date Sugar Palm—Quarterly Journal, Bengal Agricultural Department, January 1908, pp. 161-2.

[2] Published by authority of Government. See Bengal Sugar Planter, Robinson, 1849, Appendix A.

[3] Only these were actually enumerated for 1911.

These figures would seem to shew that the industry has not increased very much in the above districts as a whole, since 1848.

History of English Sugar Factories in Jessore.[1]

In the first half of the 19th century, the establishment of European sugar factories gave a considerable impulse to the manufacture. The first English factory in Lower Bengal was at Dhoba in the Burdwan district and was erected by a Mr. Blake in 1829. When his profits began to decline he formed a company which purchased the works from him for 4½ lakhs. The company had factories at Kotechandpur where they set up English machinery and also at Trimohini but failed about 1842. Kotechandpur then passed into the hands of Mr. Newhouse who brought out the first vacuum pan and Trimohini became the property of a Mr. Saintsbury who worked it for three or four years and then closed it. The factory of Chaugachha was established about the same time (1842) by Gladstone, Wyllie & Co. of Calcutta. It was first under the management of a Mr. Smith and afterwards of Mr. Macleod and it had out factories for purchase at Keshabpur, Trimohini, Jhingergachha, Narikelberia and Kotechandpur. It worked at a profit for only a year or two and after that was discontinued. About 1850, Chaugachha and Kotechandpur alone were in working order and they only worked occasionally, while Tahirpur which was built about 1853 by Mr. Newhouse was worked for only two years and was then sold and converted into a rum distillery.

On the whole the history of the English sugar refineries is not a record of success. The truth is that after they had given a stimulus to the cultivation of the date palm, the trade which they had created was appropriated by native merchants. The demand for native refined sugar was greater than that for the first rate sugar, manufactured by European means, and the Europeans consequently lost the trade.

The following few figures may give an idea of the extent of the palm sugar industry in Madras.

[1] Taken from the Gazetteer of the J sore District.

In 1848, Madras is said to have produced[1] 40,000 tons of cane jaggery and 25,000 tons of palm jaggery, but Watt says the palm sugar figures must have been underestimated.[2]

Year.	Tons of palm jaggery.
1883–84	87,200
1884–85	83,700
1885–86	74,000

The accompanying figures shew the total number of palms of all kinds tapped for sugar making for the past five years in the following Madras districts of Godavari, Kistna (5 taluks), South Canara, Malabar and Tinnevelly. The figures were kindly furnished by the Director of Agriculture, Madras.

Year.	No. of palms.
1906–07	2,636,655
1907–08	2,588,410
1908–09	2,133,139
1909–10	1,934,820
1910–11	2,342,446

Messrs. Parry & Co. have kindly sent me the following figures for the last three years shewing the quantity of jaggery bought by themselves or other refiners and distillers in the Madras Presidency. At the same time it must be remembered that a very large quantity passes into direct consumption.

	1908–09.	1909–10.	1910–11.
	Tons.	Tons.	Tons.
Palm jaggery	25,400	29,000	26,100
Sugar manufactured	10,800	13,000	13,000

[1] Watt's Dictionary of Economic Products, Vol. VI, Part 2, p. 226.
[2] *Idem.*, p. 227.

PART III.

OTHER SUGAR-PRODUCING PALMS.

Phœnix sylvestris or the wild date is practically the only palm used for sugar production in Bengal. It is also the commonest one used for this purpose in Mysore but it is very little used elsewhere in India. There are various palms whose juice is used in India for the production of sugar.

Borassus flabelliformis.—The fan palm or common toddy palm is the one most used for sugar production in Madras and Burma.[1] It is also used to a small extent for this purpose in the Sunderbans.

Cocos nucifera.—The coconut palm is used to a large extent in Madras for the manufacture of sugar, though it is not so much used there as the fan palm.

Nipa fruticans.—This plant grows in low lying lands by the sea in the Sunderbans, Chittagong, Burma and the Andaman Islands. An alcoholic drink is made from it and I understand a small amount of sugar also. In the Philippine Islands it is used to a considerable extent for sugar making and alcohol[2] production.

Caryota Urens, the sago palm of India, is used to a small extent in Madras. It has been credited with enormous yields at Malabar.

Arenga saccharifera is not used in India for sugar production but is much used for this purpose in the Dutch East Indies.[3] Robinson[4] remarks that these last two palms merit the attention of the Bengal planters.

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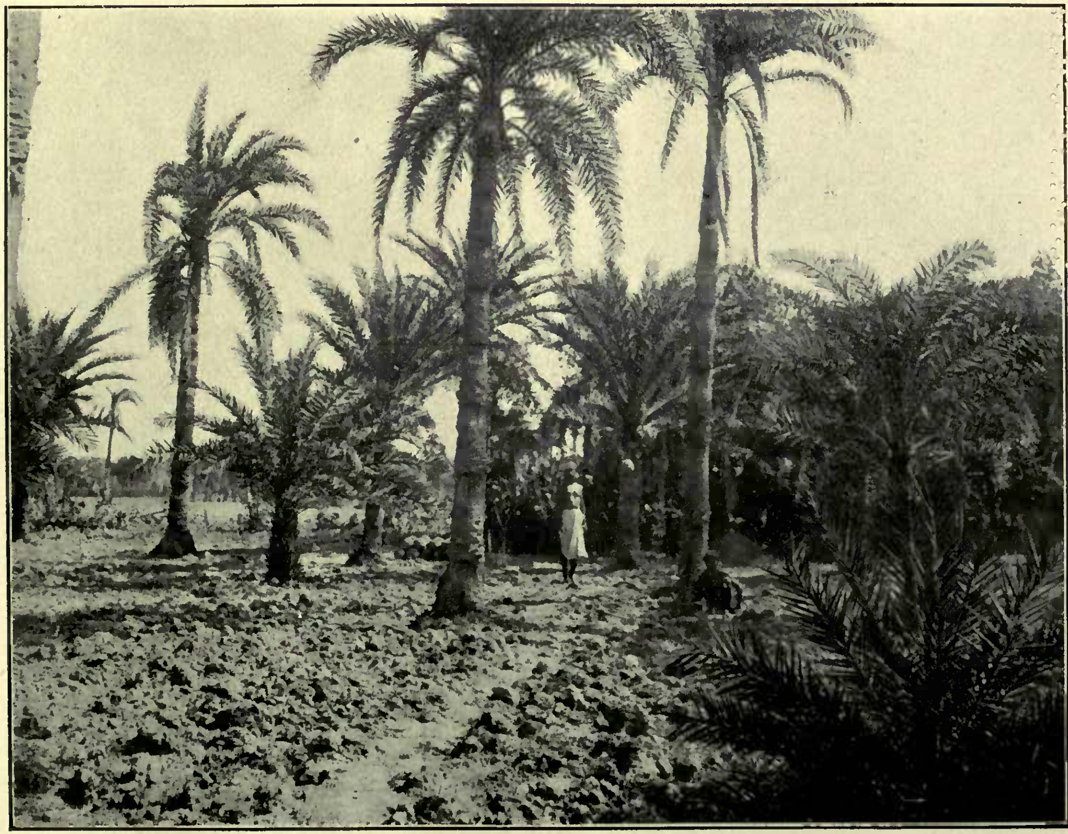
[1] Agricultural Journal of India, Vol. VI, Part IV, p. 369.
[2] Philippine Jour. of Sci., April 1911, Vol. VI, No. 2, p. 110.
[3] Jour. Roy. Soc. of. Arts, April 21st, 1911.
[4] Prize Essay, 1858.

PLATE II.



Date Garden.—General View. In background can be seen the shelter for boiling the juice and also the co llecting pots piled for smoking.

PART IV.

The Agriculture of the Date Palm.

The Date Palm, *Phœnix sylvestris,* grows well over the greater part of India but it is mainly in Bengal and Mysore that it is cultivated for sugar production. Large natural forests occur in Central India and H. D. Chatterjee[1] is experimenting on date sugar production in those tracts.

Area.—In Bengal the total area under its cultivation is put at 150 square miles, 30 square miles of this being in the Jessore district alone.[2]

The industry is chiefly confined to the districts of Jessore, Khulna, Nuddea, Faridpur, Backerganj and 24-Parganas.

Soil.—Kanjilal[3] says that the wild date prefers humid alluvial soils and a moist climate, and further that it is extremely sensitive to shade and avoids clayey soils and water logging.

Cultivation.—The seeds, which are ripe in May, are sown in a nursery in the rains. The young plants are ready for planting out in the following April or May after the first showers of the season have moistened the ground. Kanjilal[4] says they are planted nine feet apart each way : that is 543 trees per acre. Robinson[5] says ten feet apart which is equivalent to 441 trees per acre.

Not much regard however seems to be paid to order or regularity of distance apart of the trees. In the writer's observation trees in plantations are set at any thing from 9 to 17 feet apart and

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[1] Is it an experiment or a natural industry. Haridas Chatterjee. Central India Press Mhow, 1901.

[2] Hunter's Imperial Gazetteer, Vol. VII, p. 187.

[3] Indian Forester, December 1892, p. 451.

[4] Loc. cit.

[5] Prize Essay 1858.

he would consider 10 feet apart as quite the minimum distance possible. When 4 or 5 years old the green upper leaves are tied up like a bouquet, the lower yellow coloured ones being cut away. At 5 to 6 years old the stem is about $1\frac{1}{2}$ feet high and the tree is ready to be tapped. The spaces between the trees are generally occupied by oil seeds, pulses such as *Phaseolus radiatus* and *Cajanus indicus* or by linseed. Later on even Aus paddy is sometimes grown under the trees. Thus the cost of a native plantation is reduced, whilst the trees benefit by the ploughing, which loosens the earth, and the ground is kept free from weeds.

The quality of the cultivation in date gardens varies greatly. Some of the gardens I have seen have been wonderfully clean, whilst others have been almost choked up with jungle growth.

PLATE III.

Apparatus used in tapping.

PART V.

Tapping.

The usual articles required for this work consist of (1) a rope (*dara*) 9 ft. long and 1 to 1½ inches thick, which is loosely tied round the operator and the tree, and by means of which a man can climb rapidly and safely ; (2) a plaited palmyra leaf bag (the *thungi*), about 1 foot deep, in which are carried the *daws*, spouts and other articles and to which are attached a wooden hook and two loops of string, the loops going round the waist of the man, and being tied in front and the hook suspending an earthen pot; (3) a piece of canvas or goatskin (the *kolach*), 1 ft. wide, which is tied on the man's back to protect him from the rubbing action of the climbing rope, and (4) three *daws* (bill hooks), one heavy and two lighter ones. All the above are shown in Plate III.

The tapping is a delicate operation commenced in October and done in several stages. With the heavy *daws*, all the old leaves are cut off below the crown, and all the leaves from one side of it leaving only a few at the top, the bases of the petioles and the sheaths being carefully removed (See Plate IV). Then with the lighter *daws* the outer zone of the loose soft tissue is pared off in long slices leaving only a thin covering of it over the sap-supplying inner zone which corresponds to the woody zone in the older wood of all palms. Very great care must be taken not to expose this inner tissue at this stage, otherwise the tree is sure to rot and die, as often happens when the operation is entrusted to inexperienced hands. The experts at this work are called *Siulis* or *Gachis*. After this first operation the trees are given about 8 days rest, by which time the fine covering of soft tissue gets a little hardened and begins to crack. The second operation consists in removing this covering, great care

being taken not to cut into the inner zone, which is now for the first time simply exposed. Then comes a rest of 12 to 14 days which brings us to the beginning of November. The *Gachi* as a rule divides his trees into six convenient groups called *palas*, each containing 50 or 60 trees, the number which he can operate on in one day, 300 to 400 being the total number which one man can manage. Next after midday he cuts two eye-shaped notches 3—4 inches long and about ¼ inch deep at the base, their lower sides being straight and converging to a point, below which a split bamboo spout is driven into the tree. About 3 or 4 o'clock in the afternoon an earthenware pot is suspended under the spout and the juice which trickles down is collected. The pots are removed early next morning, at 6 or 7 A.M., before the sun gets on them, and the juice boiled into sugar. On the following night juice is again collected generally without renewing the cut though the surface is as a rule cleaned with the hard stem of a palm-leaf. A much smaller quantity is generally obtained than on the first night. On the third evening also more juice is, as a rule, collected, but it is only small in amount and of very poor quality. Each night's juice has a distinctive name given to it. That of the first night is called *Jiran* (rest), of the second night *Dokat* (second cut) and of the third night *Tekat* (third cut). On the fourth and fifth nights no juice is collected. After six days the cut is renewed a little, and for three days juice is again obtained, being given the same names as before. The tapping process goes on in this way throughout the season. The first 2—3 weeks' supply is very valuable, for the gur produced from it, called *Noten-gur*, has a very pleasant smell and is much appreciated by the consumers. It fetches a high price.

Of course it is not to be supposed that in all cases such a regular system of tapping is carried out. Sometimes the trees are cut for 2—3 days in succession, and sometimes they may be cut every fourth day. But such frequent tapping soon destroys the trees.

The *daws* (bill hooks) require much attention. They are daily sharpened on a piece of dry wood sprinkled over with fine sand while

PLATE IV.

THE *gachi* (TAPPER) AT WORK.

the *daws* are new, but with dry potter's clay afterwards. They may even require tempering once or twice in a season. The tip is especially looked to. If too sharp and pointed, it cuts into the trees and injures them, sometimes fatally, and if too blunt, it tears the tissues, whereas a clean cut must be obtained.

The following plan illustrates the daily round of work in the garden:—

ORDER OF TAPPING.

Days.	Divisions of the garden.	Cuts.
1st day	1st portion ..	Jiran or 1st cut.
2nd „	1st „ ..	Dokat.
	2nd „ ..	Jiran.
3rd „	1st „ ..	Tekat.
	2nd „ ..	Dokat.
	3rd „ ..	Jiran.
4th „	1st „ ..	Rest.
	2nd „ ..	Tekat.
	3rd „ ..	Dokat.
	4th „ ..	Jiran.
5th „	1st „ ..	Rest 2nd day.
	2nd „ ..	„ 1st „
	3rd „ ..	Tekat.
	4th „ ..	Dokat.
	5th „ ..	Jiran.
6th	1st „ ..	Rest 3rd „
	2nd „ ..	„ 2nd „
	3rd „ ..	„ 1st „
	4th „ ..	Tekat.
	5th „ ..	Dokat.
	6th „ ..	Jiran.

As a rule there is no dokat or tekat juice in November. In December dokat juice as well as jiran is obtained. In January we have jiran, dokat and tekat juices.

Towards the end of January and thence till the end of the season, the trees are slightly cut for dokat juice as well as for jiran. That is, they are cut on two successive nights (1) for the jiran, (2) for dokat. Dokat juice yielded from a surface cut afresh is called *dokat pocha*. A fair amount of juice drops from the cut

surface during the day. This is collected and is called '*Ola.*' It is very poor in quality and is boiled into molasses which is sold for mixing with tobacco at 12 annas per maund (*katcha*). In normal cases the cut is renewed week after week until about the middle of March, by which time a very deep notch is made into the tree, reaching $\frac{1}{3}$ or at times $\frac{1}{2}$ through it. Each succeeding cut tends to go slightly higher up than the previous one. The next year's cut is made on the opposite side but at a slightly higher level, the tree having grown in height in the meantime. This continued year after year gives the plant its characteristic zig-zag appearance. It is noticeable that trees are almost always tapped only on the East and West side. The first tapping generally takes place on the East side.

The writer has seen trees which have been tapped continuously for almost fifty years. This can be told by the number of notches. The age of a date tree which has been tapped regularly can thus be easily told by adding the number of notches to 6 years, the age at which as a rule, tapping first takes place. The average sap-yielding life of a tree, however, is probably not much more than 25 years. Even then, the old tree is still of some considerable value as fuel.

The yield of sap is greatest in mid winter. The sap collected on calm and cloudless nights gives gur of the best quality. Cloudy and foggy nights affect both the quality and quantity of the juice adversely. It is said that in January when the trees are in full inflorescence, the sap becomes very poor in sugar, though profuse in quantity, and as a rule does not produce good crystals.

Smoking the Pots.—The earthen pots in which the juice is collected are well smoked every morning as soon as they are emptied. It is noticeable, that after smoking the pots are always kept mouth downward on the ground all day, until they are hung up on the trees again in the afternoon. The smoking is done by putting a number of pots mouth downwards over a heap of rubbish such as leaves, date leaves or *bhusa* and then firing the rubbish. The

interior of the pots is thus thoroughly smoked. The treatment is over in a few minutes, and is supposed to help to keep the juice from fermentation. Kanjilal[1] says the smoking gives the pots a glazed surface, and also the alkaline salts of the smoke neutralise acidity, and the heat kills any ferments which may have been produced.

From our own observation we consider the heating effect must be almost negligible as the pots seldom become more than just warm.

A number of measurements were made of the actual temperature to which the insides of the pots attain.

A maximum thermometer was held close to the advancing flame. The highest temperature thus recorded was 53·6° C.

The following are the temperatures reached by a number of pots during the smoking. The temperature was determined by removing the pot immediately the flame had passed it, inserting the thermometer and closing the mouth with a duster.

	Temp. °C.		Temp. °C.
1	26·0	7	33·0
2	34·0	8	33·0
3	27·0	9	29·0
4	26·5	10	29·5
5	28·5	11	51·5
6	28·5	12	51·5

It seems, therefore, uncommon for the temperature to reach much higher than 32° C. Numbers 11 and 12 were exceptionally hot pots and one only occasionally meets with pots which have been so strongly heated.

The following experiments were carried out to find the effect of smoking on preserving the juice.

In the earlier experiments two pots were attached to the cut surface of the tree. One of the pots was smoked and the other

[1] Indian Forester, Dec. 1892, p. 454.

unsmoked. Two V shaped grooves were cut in the juice yielding surface instead of the usual one and two pegs inserted, one for each of the two pots. The juice from each pot was analysed next morning. Numerous experiments were carried out on these lines but no definite result was obtained. Sometimes the smoked and sometimes the unsmoked gave the best juice. It was decided that tests carried out in this way are useless because—

(1) It is impossible to collect equal amounts of juice in each pot. Indications were obtained that small amounts of juice fermented much more rapidly than large amounts.

(2) It is possible that juice yielded from different parts of the same cut surface is not uniform in composition.

(3) It has been shewn (pp. 327-328) that juice yielded at different periods during the night varies in composition. Therefore unless the rates of flow of juice into the two pots are relatively the same throughout the night, we shall get variations in composition of the juice due to this cause.

It was frequently noticed that the juice in the smoked pots was quite clear, whereas the juice from the unsmoked pots was cloudy.

The effect of smoking was finally decided in the following way:

Four quite new pots were obtained. Two of them were smoked and two left unsmoked. During the evening a large quantity of juice was collected. This was analysed and measured. It was then divided into four equal portions one of which was put into each of the four pots, which were then hung up on trees near the bungalow during the evening. Next morning the juice was analysed from each of the four pots.

The experiment was carried out in an exactly similar way on three successive days. The results obtained are here set out. Jiran juice was used in each case.

Expt.	Date.		Time.	Volume of juice c.c.	Treatment.	Sucrose gms. per 100 c.c.	Reducing sugar gms. per 100 c.c.
1	26-2-11	..	7-30 P.M.	4,800	Original	15·44	0·57
	27-2-11	..	8 A.M.	1,200	Unsmoked	14·12	1·94
	"	..	do.	do.	do.	13·59	2·43
	"	..	do.	do.	Smoked	14·77	1·47
	"	..	do.	do.	do.	14·18	1·94
2	27-2-11	..	9 A.M.	4,800	Original	13·22	0·75
	28-2-11	..	7-30 A.M.	1,200	Unsmoked	9·95	3·74
	"	..	do.	do.	do.	8·96	4·86
	"	..	do.	do.	Smoked	10·72	2·87
	"	..	do.	do.	do.	10·80	3·24
3	28-2-11	..	8-30 P.M.	5,200	Original	11·75	0·97
	1-3-11	..	8 A.M.	1,300	Unsmoked	6·44	4·86
	"	..	do.	do.	do.	6·33	4·86
	"	..	do.	do.	Smoked	7·48	4·04
	"	..	do.	do.	do.	7·02	4·4

A similar experiment was carried out in February 1912. Four new pots were used for collecting juice without previous smoking. The following morning two of these were smoked by the native process. That evening a quantity (900 c.c.) of juice was collected and analysed. 225 c.c. was then put into each of the four pots, and these were hung on trees overnight.

The table shows the result :—

Date.		Time.	Volume of juice c.c.	Treatment.	Sucrose gms. per 100 c.c.	Reducing sugar gms. per 100 c.c.
6-2-12	..	8 P.M.	900	Original	13·34	0·62
7-2 12	.	7-30 A.M.	225	Unsmoked	8·39	4·00
"	..	do.	225	do.	9·48	3·33
"	..	do.	225	Smoked	11·36	2·50
"	..	do.	225	do.	Spoilt	3·33

All the juices used in February 1911 for this experiment were faintly acid. The juice used in 1912 was distinctly alkaline.

In every case we see that the juice kept in the smoked pots has not deteriorated so much as that in the unsmoked ones. We must conclude that smoking has a beneficial effect.

It has been suggested that this beneficial effect is due to the alkalinity of the smoke. Accordingly, to test this point, we burnt quantities of the fuel normally used by the native for smoking the pots and aspirated the smoke through measured amounts of standard acid. As a result of several experiments it was found that the smoke contained no measurable amount of alkaline constituents.

It seems possible that the beneficial effects of the smoke may be due to the presence in it of some antiseptic body such as formaldehyde. It is proposed to make an examination of the smoke constituents in order to test this point.

CHART NO. 1.

TREE NO. 3.

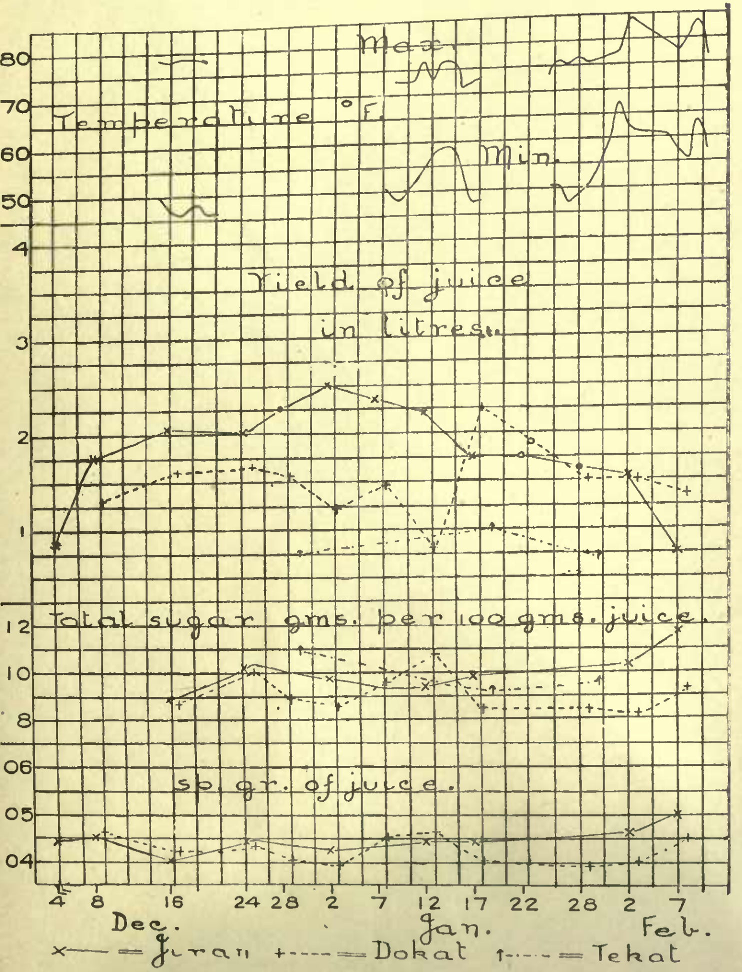


CHART NO. 2.

TREE NO. 11.

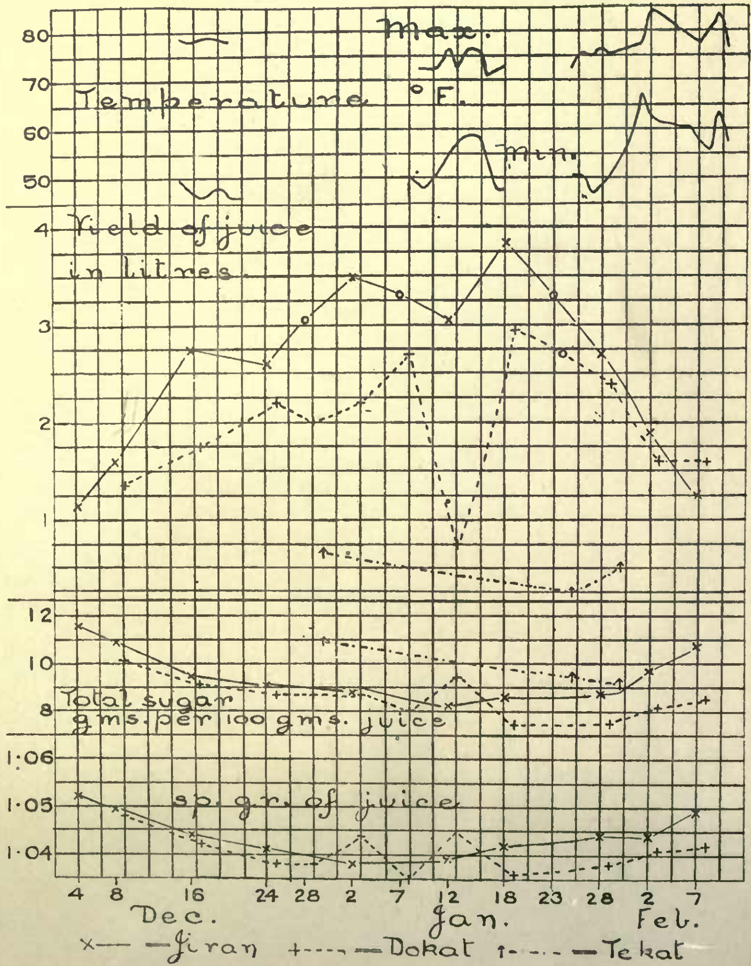


CHART NO. 3.

TREE NO. 16.

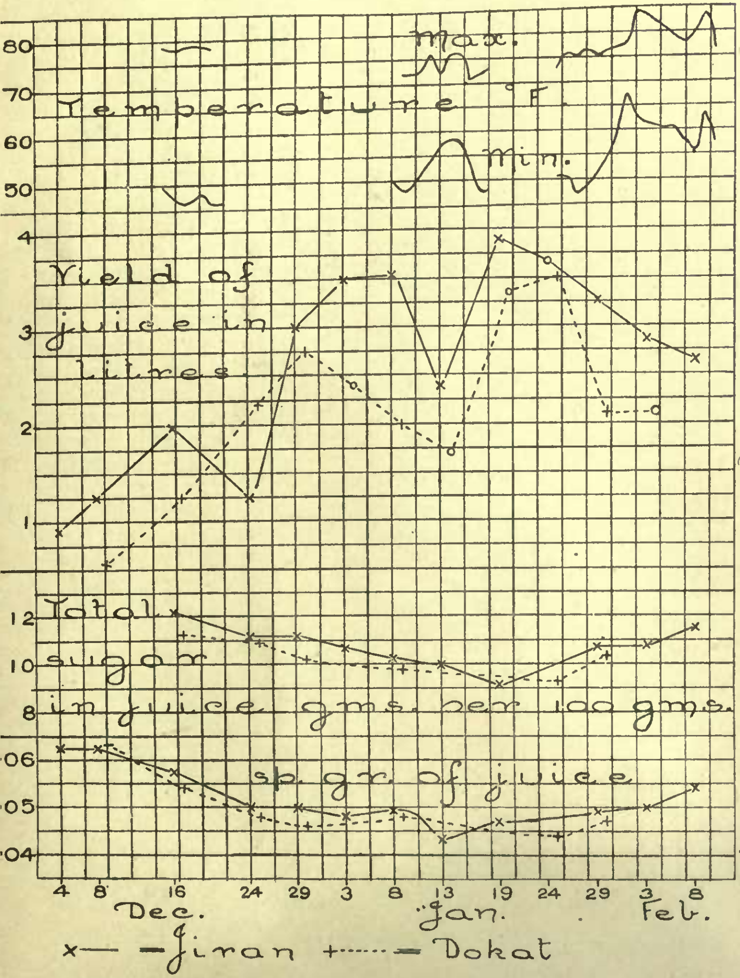
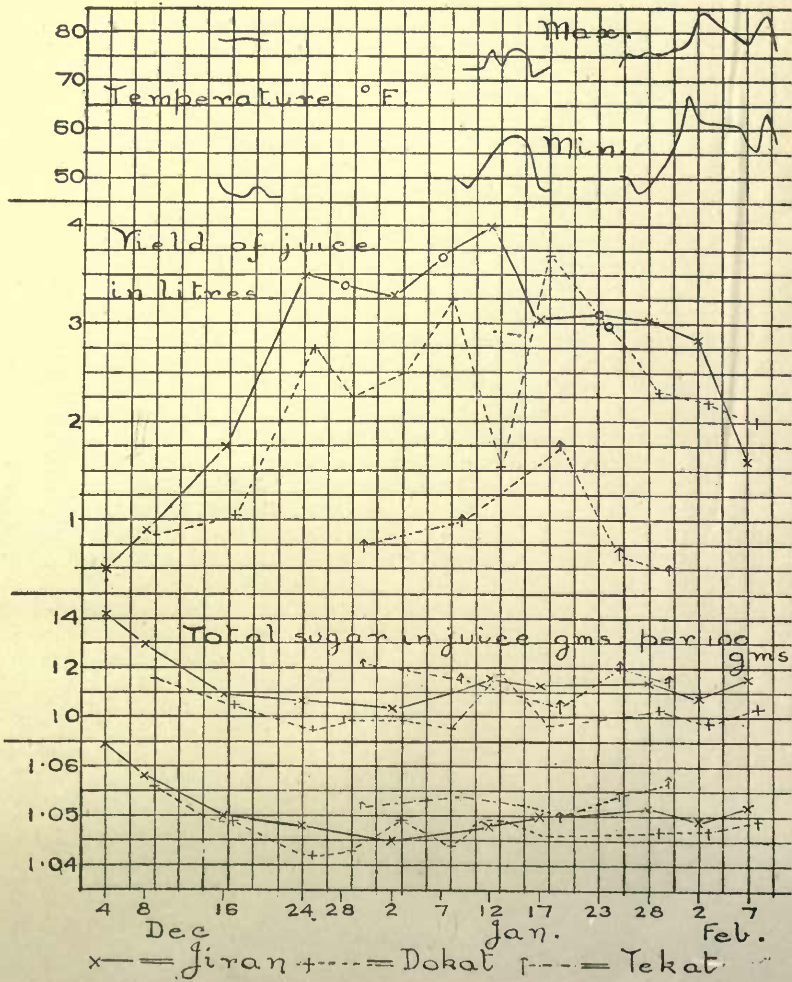


CHART NO. 4.

TREE NO. 20.



PART VI.

TOURS.

The work is the outcome of two visits to Jessore district. It was first taken up at the end of January 1911 by which time, however, the greater part of the sugar producing season is over. The results obtained on that occasion could hardly be used to judge of the capabilities of the industry, for it is well recognised that towards the end of the season there is a marked falling-off in the quality of the produce.

Accordingly it was decided to spend the greater part of the cold weather 1911-12 in the date sugar districts. By this means only could reliable information be obtained.

In the first place it is of great importance to determine what is the average yield of sugar per tree per season. The estimates of this up to the present have varied within very wide limits.

The losses during manufacture had to be investigated and opinion had to be formed whether or no the industry was possible and worthy of improvement. In this case then data had to be obtained in order to show in what directions the industry could be improved.

The first visit to Jessore district lasted from January 31st to March 6th, 1911. The second and main tour lasted from November 29th to February 14th, 1912. Thus practically the whole of the date sugar producing season was included. About 2,000 individual measurements of yields of juice per tree were made during this time in different parts of the district. The specific gravity of the juice was taken in each case. During the second tour, a garden was selected near Kotechandpur which was kept under careful observation. In this garden 20 trees were taken at random and

the juice carefully measured from them throughout the season, and from four of these trees the juice was regularly analysed in order to see how the amount of sugar in the juice varied throughout the season.

Various other experiments were carried out, such as the loss of sugar during boiling and so on, and these are all described in the subsequent pages.

PART VII.

JUICE.

YIELD OF JUICE PER TREE.

Our observations show that most of the estimates hitherto made are much too high. Twenty trees of various ages and in various conditions were selected in the same garden and were numbered 1 to 20 and metal labels with the numbers stamped on them were nailed into the trees. Whenever the trees yielded, the juice was, if possible, measured and its specific gravity taken. In the case of trees Nos. 3, 11, 16, 20, the amounts of sucrose and reducing sugar were regularly determined. The data obtained are all entered in the tables. This experiment was carried out in the cold weather 1911-12. Tapping operations commenced very late this season because there was a large area of jute grown in Jessore and the harvesting, retting and marketing of this delayed the date sugar operations beyond the normal. The above trees in consequence did not yield their first juice till December 4th. Moreover it was not possible to always measure the juice. For those days which were missed figures have been inserted in brackets and these have been computed from a consideration of the yields given on the preceding and succeeding occasions. The data for four of the trees have been plotted as curves in Charts Nos. 1—4.

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
Tree No. 1	4th Dec. 1911 ..	Jiran ..	600	1·058
8 years tapped.	8th „ „ ..	„ ..	1,150	1·056
	9th „ „ ..	Dokat ..	1,000	1·058
	16th „ „ ..	Jiran ..	1,950	1·052
	17th „ „ ..	Dokat ..	1,250	1·050
	24th „ „ ..	Jiran ..	2,150	1·050
	25th „ „ ..	Dokat ..	(1,650)	....
	28th „ „ ..	Jiran ..	(2,250)	....
	29th „ „ ..	Dokat ..	(1,650)	....
	2nd Jan. 1912 ..	Jiran ..	(2,250)	....
	3rd „ „ ..	Dokat ..	(1,650)	....
	7th „ „ ..	Jiran ..	(3,000)	....
	8th „ „ ..	Dokat ..	(2,000)	....
	12th „ „ ..	Jiran ..	2,350	1·051
	13th „ „ ..	Dokat ..	900	1·053
	17th „ „ ..	Jiran ..	2,200	1·052
	19th „ „ ..	Tekat ..	1,500	1·050
	25th „ „ ..	„ ..	500	1·054
	28th „ „ ..	Jiran ..	2,100	1·054
	29th „ „ ..	Dokat ..	1,650	1·052
	30th „ „ ..	Tekat ..	500	1·058
	2nd Feb. 1912 ..	Jiran ..	(1,700)	....
	3rd „ „ ..	Dokat ..	1,250	1·050
	7th „ „ ..	Jiran ..	1,300	1·052
	8th „ „ ..	Dokat ..	1,750	1·049
		Total ..	40,250 = 42,343 gms. (*). = 93·37 lbs.	

* In this and succeeding tables, the weight in grammes of juice was determined by multiplying the number of c.c. by the average specific gravity, which was obtained by adding up and averaging all the specific gravity figures.

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 2	4th Dec. 1911 ..	Jiran ..	200	....
2 years tapped male tree.	8th „ „ ..	„ ..	950	1·060
	9th „ „ ..	Dokat ..	600	....
	16th „ „ ..	Jiran ..	1,350	1·049
	17th „ „ ..	Dokat ..	750	1·049
	24th „ „ ..	Jiran ..	2,500	1·043
	25th „ „ ..	Dokat ..	(850)	....
	28th „ „ ..	Jiran ..	(1,900)	....
	29th „ „ ..	Dokat ..	(750)	....
	2nd Jan. 1912 ..	Jiran ..	(1,900)	....
	3rd „ „ ..	Dokat ..	(750)	....
	7th „ „ ..	Jiran ..	(1,900)	....
	8th „ „ ..	Dokat ..	900	1·050
	12th „ „ ..	Jiran ..	1,250	1·049
	13th „ „ ..	Dokat ..	550	1·047
	18th „ „ ..	Jiran ..	1,250	1·053
	19th „ „ ..	Dokat ..	600	1·050
	23rd „ „ ..	Jiran ..	(1,500)	....
	24th „ „ ..	Dokat ..	(1,050)	....
	28th „ „ ..	Jiran ..	1,750	1·051
	29th „ „ ..	Dokat ..	1,500	1·042
	30th „ „ ..	Tekat ..	500	1·048
	2nd Feb. 1912 ..	Jiran ..	1,250	1·051
	3rd „ „ ..	Dokat ..	1,250	1·042
	7th „ „ ..	Jiran ..	750	1·054
	8th „ „ ..	Dokat ..	1,950	1·043

Total ... 30,450

= 31,792 gms.
= 70·50 lbs.

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 4	4th Dec. 1911 ..	Jiran ..	500	1·060
15 years tapped.	8th ,, ,, ..	,, ..	850	1·054
	9th ,, ,, ..	Dokat ..	750	1·052
	16th ,, ,, ..	Jiran ..	1,350	1·045
	17th ,, ,, ..	Dokat ..	750	1·046
	24th ,, ,, ..	Jiran ..	1,150	1·044
	25th ,, ,, ..	Dokat ..	(500)	....
	28th ,, ,, ..	Jiran ..	(900)	....
	29th ,, ,, ..	Dokat ..	(500)	....
	2nd Jan. 1912 ..	Jiran ..	(900)	....
	3rd ,, ,, ..	Dokat ..	(500)	....
	7th ,, ,, ..	Jiran ..	(900)	....
	8th ,, ,, ..	Dokat ..	250	1·056
	12th ,, ,, ..	Jiran ..	650	1·050
	13th ,, ,, ..	Dokat ..	100	....
	18th ,, ,, ..	Jiran ..	950	1·051
	19th ,, ,, ..	Dokat ..	400	1·054
	23rd ,, ,, ..	Jiran ..	(950)	....
	24th ,, ,, ..	Dokat ..	(450)	....
	28th ,, ,, ..	Jiran ..	950	1·049
	29th ,, ,, ..	Dokat ..	No pot.	
	2nd Feb. 1912 ..	Jiran ..	900	1·046
	3rd ,, ,, ..	Dokat ..	1,000	1·039
	7th ,, ,, ..	Jiran ..	750	1·043
	8th ,, ,, ..	Dokat ..	(750)	....
		Total ..	17,650 = 18,532 gms. = 40·77 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 5	4th Dec. 1911 ..	Jiran ..	850	1·062
10 years tapped.	8th ,, ,, ..	,, ..	1,350	1·060
	9th ,, ,, ..	Dokat ..	1,000	1·062
	16th ,, ,, ..	Jiran ..	1,850	1·057
	17th ,, ,, ..	Dokat ..	1,000	1·056
	24th ,, ,, ..	Jiran ..	2,500	1·053
	25th ,, ,, ..	Dokat ..	(1,650)	....
	28th ,, ,, ..	Jiran ..	(2,850)	....
	29th ,, ,, ..	Dokat ..	(2,000)	....
	2nd Jan. 1912 ..	Jiran ..	(3,000)	....
	3rd ,, ,, ..	Dokat ..	(2,150)	....
	7th ,, ,, ..	Jiran ..	(3,100)	....
	8th ,, ,, ..	Dokat ..	2,300	1·048
	12th ,, ,, ..	Jiran ..	3,200	1·046
	13th ,, ,, ..	Dokat ..	1,350	1·050
	18th ,, ,, ..	Jiran ..	3,500	1·053
	19th ,, ,, ..	Dokat ..	2,450	1·047
	23rd ,, ,, ..	Jiran ..	(3,300)	....
	24th ,, ,, ..	Dokat ..	(2,700)	....
	25th ,, ,, ..	Tekat ..	600	1·056
	28th ,, ,, ..	Jiran ..	3,050	1·052
	29th ,, ,, ..	Dokat ..	3,000	1·046
	30th ,, ,, ..	Tekat ..	1,000	1·054
	2nd Feb. 1912 ..	Jiran ..	2,750	1·052
	3rd ,, ,, ..	Dokat ..	1,600	1·047
	7th ,, ,, ..	Jiran ..	1,750	1·056
	8th ,, ,, ..	Dokat ..	2,500	1·049
		Total ..	58,350	
			= 61,267 gms.	
			= 134·78 lbs.	

Notes on the trees.	Date.	Jiran, Dokat, or Tekat.	Volume c. c.	Specific gravity.
No. 7 13 years tapped female.	4th Dec. 1911 ..	Jiran ..	900	1·053
	8th ,, ,, ..	,, ..	(1,100)	....
	9th ,, ,, ..	Dokat ..	(800)	....
	16th ,, ,, ..	Jiran ..	1,300	1·061
	17th ,, ,, ..	Dokat ..	800	1·060
	24th ,, ,, ..	Jiran ..	2,200	1·053
	25th ,, ,, ..	Dokat ..	(2,000)	....
	28th ,, ,, ..	Jiran ..	(2,300)	....
	29th ,, ,, ..	Dokat ..	(2,000)	....
	2nd Jan. 1912 ..	Jiran ..	(2,300)	....
	3rd ,, ,, ..	Dokat ..	(1,800)	....
	7th ,, ,, ..	Jiran ..	(3,200)	....
	8th ,, ,, ..	Dokat ..	2,650	1·050
	9th ,, ,, ..	Tekat ..	650	1·059
	12th ,, ,, ..	Jiran ..	3,800	1·053
	13th ,, ,, ..	Dokat ..	2,000	1·052
	17th ,, ,, ..	Jiran ..	3,250	1·053
	18th ,, ,, ..	Dokat ..	3,850	1·048
	19th ,, ,, ..	Tekat ..	2,100	1·051
	23rd ,, ,, ..	Jiran ..	(3,500)	....
	24th ,, ,, ..	Dokat ..	(3,500)	....
	25th ,, ,, ..	Tekat ..	800	1·057
	28th ,, ,, ..	Jiran ..	3,750	1·052
	29th ,, ,, ..	Dokat ..	4,150	1·048
	30th ,, ,, ..	Tekat ..	1,500	1·053
	2nd Feb. 1912 ..	Jiran ..	3,200	1·049
	3rd ,, ,, ..	Dokat ..	3,400	1·046
	7th ,, ,, ..	Jiran ..	2,600	1·054
	8th ,, ,, ..	Dokat ..	3,250	1·051
		Total ..	68,650 =72,285 gms. =159·03 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c. c.	Specific gravity.
No. 8 10 years tapped.	4th Dec. 1911 ..	Jiran ..	1,850	1·054
	8th ,, ,, ..	,, ..	1,500	1·050
	9th ,, ,, ..	Dokat ..	1,050	1·050
	16th ,, ,, ..	Jiran ..	1,750	1·041
	17th ,, ,, ..	Dokat ..	600	1·046
	24th ,, ,, ..	Jiran ..	1,750	1·039
	25th ,, ,, ..	Dokat ..	(850)	....
	28th ,, ,, ..	Jiran ..	(1,700)	....
	29th ,, ,, ..	Dokat ..	(950)	....
	2nd Jan. 1912 ..	Jiran ..	(1,700)	....
	3rd ,, ,, ..	Dokat ..	(950)	....
	8th ,, ,, ..	Jiran ..	1,650	1·038
	9th ,, ,, ..	Dokat ..	1,000	1·038
	13th ,, ,, ..	Jiran ..	1,350	1·035
	14th ,, ,, ..	Dokat ..	(1,100)	....
	19th ,, ,, ..	Jiran ..	1,450	1·039
	20th ,, ,, ..	Dokat ..	(1,100)	....
	24th ,, ,, ..	Jiran ..	(1,400)	....
	25th ,, ,, ..	Dokat ..	1,250	1·038
	26th ,, ,, ..	Tekat ..	200	....
	29th ,, ,, ..	Jiran ..	1,050	1·038
	30th ,, ,, ..	Dokat ..	1,050	1·042
	3rd Feb. 1912 ..	Jiran ..	1,450	1·040
	4th ,, ,, ..	Dokat	(1,450)	....
	8th ,, ,, ..	Jiran ..	800	1·039
	9th ,, ,, .. 10th ,, ,, ..	Owing to rain no juice was collected.	....	....
		Total ..	30,150 = 31,356 gms. = 68·98 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 9 14 years tapped.	4th Dec. 1911 ..	Jiran ..	250	....
	8th ,, ,, ..	,, ..	750	1·070
	9th ,, ,, ..	Dokat ..	700	1·064
	16th ,, ,, ..	Jiran ..	1,850	1·058
	17th ,, ,, ..	Dokat ..	900	1·058
	24th ,, ,, ..	Jiran ..	3,000	1·049
	25th ,, ,, ..	Dokat ..	(2,100)	....
	28th ,, ,, ..	Jiran ..	(3,250)	....
	29th ,, ,, ..	Dokat ..	(2,300)	....
	2nd Jan. 1912 ..	Jiran ..	(3,250)	....
	3rd ,, ,, ..	Dokat ..	(2,300)	....
	8th ,, ,, ..	Jiran ..	3,500	1·053
	9th ,, ,, ..	Dokat ..	2,500	1·047
	13th ,, ,, ..	Jiran ..	2,550	1·049
	14th ,, ,, ..	Dokat ..	(2,300)	....
	19th ,, ,, ..	Jiran ..	4,000	1·050
	20th ,, ,, ..	Dokat ..	(3,250)	....
	24th ,, ,, ..	Jiran ..	(4,000)	....
	25th ,, ,, ..	Dokat ..	3,750	1·041
	26th ,, ,, ..	Tekat ..	750	1·056
	29th ,, ,, ..	Jiran ..	2,900	1·052
	30th ,, ,, ..	Dokat ..	3,150	1·045
	3rd Feb. 1912 ..	Jiran ..	2,850	1·050
	4th ,, ,, ..	Dokat ..	(3,100)	....
	8th ,, ,, ..	Jiran ..	4,250	1·041
	9th ,, ,, 10th ,, ,,	Owing to rain no juice was collected.	....	....
		Total ..	63,500 =66,800 gms =147·29 lbs	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 10 14 years tapped.	4th Dec. 1911 ..	Jiran ..	300	1·052
	8th ,, ,, ..	,, ..	700	1·056
	9th ,, ,, ..	Dokat ..	800	1·044
	16th ,, ,, ..	Jiran ..	1,350	1·043
	17th ,, ,, ..	Dokat ..	950	1·041
	24th ,, ,, ..	Jiran ..	1,700	1·041
	25th ,, ,, ..	Dokat ..	(1,000)	....
	28th ,, ,, ..	Jiran ..	(1,750)	....
	29th ,, ,, ..	Dokat ..	(1,000)	....
	2nd Jan. 1912 ..	Jiran ..	(1,800)	....
	3rd ,, ,, ..	Dokat ..	(1,000)	....
	8th ,, ,, ..	Jiran ..	1,800	1·044
	9th ,, ,, ..	Dokat ..	1,000	1·047
	13th ,, ,, ..	Jiran ..	1,750	1·046
	14th ,, ,, ..	Dokat ..	(1,600)	....
	19th ,, ,, ..	Jiran ..	2,000	1·047
	20th ,, ,, ..	Dokat ..	(1,800)	....
	24th ,, ,, ..	Jiran ..	(2,200)	....
	25th ,, ,, ..	Dokat ..	1,900	1·043
	26th ,, ,, ..	Tekat ..	700	1·050
	29th ,, ,, ..	Jiran ..	1,500	1·050
	30th ,, ,, ..	Dokat ..	1,550	1·045
	3rd Feb. 1912 ..	Jiran ..	1,000	1·053
	4th ,, ,, ..	Dokat ..	(1,000)	....
	8th ,, ,, ..	Jiran ..	1,250	1·052
	9th ,, ,, 10th ,, ,,	Owing to rain no juice was collected.	....	....
		Total ..	33,400 = 35,070 gms. = 77·32 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 12 16 years tapped male tree.	4th Dec. 1911 ..	Jiran ..	1,000	1·060
	9th ,, ,, ..	,, ..	1,500	1·052
	16th ,, ,, ..	,, ..	2,850	1·047
	17th ,, ,, ..	Dokat ..	1,400	1·048
	24th ,, ,, ..	Jiran ..	2,950	1·043
	25th ,, ,, ..	Dokat ..	(1,350)	....
	28th ,, ,, ..	Jiran ..	(3,200)	....
	29th ,, ,, ..	Dokat ..	(1,600)	....
	2nd Jan. 1912 ..	Jiran ..	(3,300)	....
	3rd ,, ,, ..	Dokat ..	(1,600)	....
	7th ,, ,, ..	Jiran ..	(3,300)	....
	8th ,, ,, ..	Dokat ..	1,300	1·047
	12th ,, ,, ..	Jiran ..	3,450	1·042
	13th ,, ,, ..	Dokat ..	2,650	1·039
	17th ,, ,, ..	Jiran ..	2,500	1·047
	18th ,, ,, ..	Dokat ..	2,500	1·042
	19th ,, ,, ..	Tekat ..	1,450	1·049
	23rd ,, ,, ..	Jiran ..	(2,400)	....
	24th ,, ,, ..	Dokat ..	(2,200)	....
	25th ,, ,, ..	Tekat ..	250	....
	28th ,, ,, ..	Jiran ..	2,200	1·050
	29th ,, ,, ..	Dokat ..	1,900	1·044
	30th ,, ,, ..	Tekat ..	250	1·054
	2nd Feb. 1912 ..	Jiran ..	2,000	1·050
	3rd ,, ,, ..	Dokat ..	1,850	1·044
	7th ,, ,, ..	Jiran ..	1,250	1·055
	8th ,, ,, ..	Dokat ..	1,085	1·043
		Total ..	54,050	
			= 56,752 gms.	
			= 125·13 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 13 12 years tapped.	4th Dec. 1911 ..	Jiran ..	100	....
	8th ,, ,, ..	,, ..	300	1·070
	16th ,, ,, ..	,, ..	1,050	1·061
	17th ,, ,, ..	Dokat ..	550	1·059
	24th ,, ,, ..	Jiran ..	1,650	1·054
	25th ,, ,, ..	Dokat ..	(1,400)	....
	28th ,, ,, ..	Jiran ..	(2,100)	....
	29th ,, ,, ..	Dokat ..	(1,800)	....
	2nd Jan. 1912 ..	Jiran ..	(2,300)	....
	3rd ,, ,, ..	Dokat ..	(2,000)	....
	7th ,, ,, ..	Jiran ..	(2,400)	....
	8th ,, ,, ..	Dokat ..	2,250	1·048
	12th ,, ,, ..	Jiran ..	2,550	1·053
	13th ,, ,, ..	Dokat ..	1,000	1·053
	17th ,, ,, ..	Jiran ..	2,250	1·052
	18th ,, ,, ..	Dokat ..	2,500	1·048
	19th ,, ,, ..	Tekat ..	1,000	1·053
	23rd ,, ,, ..	Jiran ..	(2,300)	....
	24th ,, ,, ..	Dokat ..	(2,250)	....
	25th ,, ,, ..	Tekat ..	200	....
	28th ,, ,, ..	Jiran ..	2,400	1·053
	29th ,, ,, ..	Dokat ..	2,000	1·050
	30th ,, ,, ..	Tekat ..	500	1·056
	2nd Feb. 1912 ..	Jiran ..	2,000	1·052
	3rd ,, ,, ..	Dokat ..	1,500	1·050
	7th ,, ,, ..	Jiran ..	1,300	1·052
	8th ,, ,, ..	Dokat ..	2,000	1·051
		Total ..	43,650	
			= 46,010 gms.	
			= 101·45 lbs.	

Notes on the tree.	Date.		Jiran, Dokat, or Tekat.		Volume c.c.	Specific gravity.
No. 14 16 years tapped male tree.	8th Dec. 1911	..	Jiran	..	400	1·070
	16th ,, ,,	..	,,	..	1,250	1·058
	17th ,, ,,	..	Dokat	..	900	1·054
	24th ,, ,,	..	Jiran	..	2,000	1·048
	25th ,, ,,	..	Dokat	..	(1,000)	....
	28th ,, ,,	..	Jiran	..	(2,300)	....
	29th ,, ,,	..	Dokat	..	(1,100)	....
	2nd Jan. 1912	..	Jiran	..	(2,450)	....
	3rd ,, ,,	..	Dokat	..	(1,200)	....
	7th ,, ,,	..	Jiran	..	(2,500)	....
	8th ,, ,,	..	Dokat	..	1,150	1·050
	12th ,, ,,	..	Jiran	..	2,600	1·045
	13th ,, ,,	..	Dokat	..	1,250	1·046
	18th ,, ,,	..	Jiran	..	2,800	1·048
	19th ,, ,,	..	Dokat	..	1,700	1·047
	23rd ,, ,,	..	Jiran	..	(2,300)	....
	24th ,, ,,	..	Dokat	..	(1,750)	....
	25th ,, ,,	..	Tekat	..	600	1·052
	28th ,, ,,	..	Jiran	..	1,950	1·051
	29th ,, ,,	..	Dokat	..	No pot.	
	30th ,, ,,	..	Tekat	..	650	1·052
	2nd Feb. 1912	..	Jiran	..	1,900	1·047
	3rd ,, ,,	..	Dokat	..	1,800	1·046
	7th ,, ,,	..	Jiran	..	1,000	1·052
	8th ,, ,,	..	Dokat	..	1,800	1·049
			Total	..	38,350	
					= 40,310 gms.	
					= 88·86 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 15 15 years tapped.	4th Dec. 1911 ..	Jiran ..	200	....
	8th " " ..	" ..	350	1·058
	9th " " ..	Dokat ..	....	....
	16th " " ..	Jiran ..	950	1·050
	17th " " ..	Dokat ..	....	....
	24th " " ..	Jiran ..	1,000	1·045
	25th " " ..	Dokat ..	(500)	....
	28th " " ..	Jiran ..	(1,050)	....
	29th " " ..	Dokat ..	(600)	....
	2nd Jan. 1912 ..	Jiran ..	(1,100)	....
	3rd " " ..	Dokat ..	(600)	....
	8th " " ..	Jiran ..	1,100	1·045
	9th " " ..	Dokat ..	500	1·050
	13th " " ..	Jiran ..	1,000	1·044
	14th " " ..	Dokat ..	(600)	....
	19th " " ..	Jiran ..	1,150	1·045
	20th " " ..	Dokat ..	(600)	....
	25th " " ..	Jiran ..	1,150	1·039
	26th " " ..	Dokat ..	250	1·047
	29th " " ..	Jiran ..	950	1·044
	30th " " ..	Dokat ..	(700)	....
	3rd Feb. 1912 ..	Jiran ..	700	1·045
	4th " " ..	Dokat ..	(600)	....
	8th " " ..	Jiran ..	800	1·046
	9th " " 10th " "	Owing to rain no juice was collected.	....	....
		Total ..	17,450 = 18,250 gms. = 40·24 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 17 15 years tapped.	4th Dec. 1911 ..	Jiran ..	250	....
	8th ,, ,, ..	,, ..	750	1·058
	9th ,, ,, ..	Dokat ..	750	1·058
	16th ,, ,, ..	Jiran ..	1,400	1·053
	17th ,, ,, ..	Dokat ..	500	1·056
	24th ,, ,, ..	Jiran ..	1,750	1·049
	25th ,, ,, ..	Dokat ..	(500)	....
	28th ,, ,, ..	Jiran ..	(1,800)	....
	29th ,, ,, ..	Dokat ..	(500)	....
	2nd Jan. 1912 ..	Jiran ..	(1,800)	....
	3rd ,, ,, ..	Dokat ..	(500)	....
	7th ,, ,, ..	Jiran ..	(1,800)	....
	8th ,, ,, ..	Dokat ..	550	1·057
	12th ,, ,, ..	Jiran ..	1,800	1·050
	13th ,, ,, ..	Dokat ..	750	1·054
	18th ,, ,, ..	Jiran ..	1,350	1·056
	19th ,, ,, ..	Dokat ..	750	1·056
	24th ,, ,, ..	Jiran ..	(1,550)	....
	25th ,, ,, ..	Dokat ..	(1,100)	....
	28th ,, ,, ..	Jiran ..	1,750	1·051
	29th ,, ,, ..	Dokat ..	1,500	1·046
	2nd Feb. 1912 ..	Jiran ..	2,200	1·044
	3rd ,, ,, ..	Dokat ..	1,750	1·044
	7th ,, ,, ..	Jiran ..	1,000	1·049
	8th ,, ,, ..	Dokat ..	1,500	1·049
		Total ..	29,850	
			=31,361 gms.	
			=69·23 lbs.	

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
No. 19	4th Dec. 1911 ..	Jiran ..	250	....
11 years tapped.	8th ,, ,, ..	,, ..	(700)	....
	16th ,, ,, ..	,, ..	1,150	1·047
	17th ,, ,, ..	Dokat ..	950	1·045
	24th ,, ,, ..	Jiran ..	1,600	1·042
	25th ,, ,, ..	Dokat ..	(1,050)	....
	28th ,, ,, ..	Jiran ..	(1,650)	....
	29th ,, ,, ..	Dokat ..	(1,100)	....
	2nd Jan. 1912 ..	Jiran ..	(1,700)	....
	3rd ,, ,, ..	Dokat ..	(1,100)	....
	7th ,, ,, ..	Jiran ..	(1,700)	....
	8th ,, ,, ..	Dokat ..	1,150	1·046
	12th ,, ,, ..	Jiran ..	1,750	1·043
	13th ,, ,, ..	Dokat ..	750	1·046
	18th ,, ,, ..	Jiran ..	1,900	1·045
	19th ,, ,, ..	Dokat ..	1,900	1·040
	23rd ,, ,, ..	Jiran ..	(1,600)	....
	24th ,, ,, ..	Dokat ..	(1,600)	....
	28th ,, ,, ..	Jiran ..	1,250	1·049
	29th ,, ,, ..	Dokat ..	1,400	1·042
	2nd Feb. 1912 ..	Jiran ..	800	1·048
	3rd ,, ,, ..	Dokat ..	750	1·046
	7th ,, ,, ..	Jiran ..	500	1·052
	8th ,, ,, ..	Dokat ..	Not tapped again till after the 10th.	
		Total ..	28,300	

= 29,563 gms.
= 65·26 lbs.

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.	Direct reading.	Sucrose per cent.	Reducing sugar per cent.	Total sugar per cent.
No. 11	4-12-11	Jiran ...	1,150	1·052	46·2	11·44	0·12	11·56
13 years tapped.	8-12-11	Jiran ...	1,600	1·049	42·8	10·63	0·25	10·88
	9-12-11	Dokat ...	1,350	1·048	37·6	9·34	0·76	10·10
	16-12-11	Jiran ...	2,750	1·044	35·1	8·76	0·70	9·46
	17-12-11	Dokat ...	1,750	1·042	31·9	7·97	1·16	9·13
	24-12-11	Jiran ...	2,600	1·041	35·0	8·76	0·34	9·10
	25-12-11	Dokat ...	2,200	1·038	31·1	7·80	0·84	8·64
	28-12-11	Jiran ...	(3,050)	...	...	...	...	...
	29 12 11	Dokat ...	2,000	1·038	29·6	7·43	1·25	8·68
	30-12 11	Tekat ...	650	1·048	36·5	9·05	1·90	10·95
	2-1-12	Jiran ...	3,500	1·038	33·2	8·33	0·46	8·79
	3-1-12	Dokat ...	2,200	1·044	26·1	6·53	2·23	8·76
	4-1-2	Tekat ...	(500)	...	...	...	...	...
	7-1-12	Jiran ...	(3,300)	...	...	...	...	...
	8-1-12	Dokat .	2,700	1·035	29·9	7·50	0·58	8·08
	12-1-12	Jiran ...	3,050	1·039	31·4	7·86	0·42	8·28
	13-1-12	Dokat ...	750	1·045	22·6	5·63	3·80	9·43
	18-1-12	Jiran ...	3,850	1·042	30·7	7·67	0 94	8·61
	19-1-12	Dokat ...	2,950	1·036	25·7	6·46	1·00	7·46
	23-1-12	Jiran ..	(3,300)	...	...	...	...	...
	24-1-12	Dokat ...	(2,700)	...	...	...	...	...
	25-1-12	Tekat ...	250	...	19·8	4·95	4·60	9·55
	28-1-12	Jiran ...	2,700	1,044	29·0	7·24	1·50	8·74
	29-1-12	Dokat ...	2,400	1·038	23·5	5·90	1·62	7·52
	30-1-12	Tekat ...	500	1·048	23·3	5·79	3·22	9·01
	2-2-12	Jiran ...	1,900	1·044	32·9	8·21	1·47	9·68
	3-2-12	Dokat ...	1,600	1·041	27·1	6·78	1·37	8·15
	7-2-12	Jiran ..	1,250	1·049	40·0	9·93	0·83	10·76
	8-2-12	Dokat ...	1,600	1·042	27·0	6·75	1·74	8·49

Total ... 62,100

= 64,770 gms.
= 142·82 lbs.

Notes on the tree.	Date.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.	Direct reading.	Sucrose per cent.	Reducing sugar per cent.	Total sugar per cent.
No. 16	4-12-11	Jiran ..	900	1·062	...	...	...	...
1 year tapped.	8-12-11	Jiran ..	1,000	1·062	...	...	...	...
	9-12-11	Dokat ...	550	1·062	...	...	...	...
	16-12-11	Jiran ..	2,000	1·057	46·1	11·36	0 87	12·23
	17-12-11	Dokat ...	1,250	1·054	40·0	9·88	1·35	11·23
	24-12-11	Jiran ...	1,250	1·050	43·7	10 84	0·32	11·16
	25-12-11	Dokat ...	2,200	1·048	42·0	10·44	0·54	10·98
	29-12-11	Jiran ...	3,000	1·050	42·7	10 59	0·64	11·23
	30-12-11	Dokat ...	2,750	1·046	36·8	9·16	1·03	10·19
	3-1-12	Jiran ...	3,500	1·048	38·8	9·64	1·14	10·78
	4-1-12	Dokat ...	(2,400)	...	...	...	...	...
	8-1-12	Jiran ...	3,550	1·049	38·6	9·59	0·78	10·37
	9-1-12	Dokat ...	2,000	1 048	36·3	9·02	0 83	9·85
	13-1-12	Jiran ...	2,400	1·043	24·8	6·19	3·80	9 99
	14-1-12	Dokat ...	(1,700)	...	...	...	...	...
	19-1-12	Jiran ...	3,900	1·047	27·6	6·87	2·25	9 12
	20-1-12	Dokat ...	(3,100)	...	...	...	...	...
	24-1-12	Jiran ..	(3,600)	...	...	...	...	...
	25-1-12	Dokat ...	3,500	1·044	33·5	8·36	0·94	9·30
	26-1-12	Tekat ...	2,000	1·047	37·9	9·43	0 99	10·42
	29-1-12	Jiran ...	3,250	1·049	41·4	10·28	0·51	10·79
	30-1-12	Dokat ...	2,100	1·047	34·6	8·61	1·74	10·35
	3-2-12	Jiran ...	2,850	1·050	40·3	10·00	0·73	10·73
	4-2-12	Dokat ...	(2,100)	...	...	...	...	...
	8-2-12	Jiran ...	2,650	1·054	43·0	10·63	0·95	11·58

Total ... 60,000 c.c.

= 62,922 gms
= 138·90 lbs.

Notes on the tree.	Date.	Jiran, Dokat or Tekat.	Volume c.c.	Specific gravity.	Direct reading.	Sucrose per cent.	Reducing sugar per cent.	Total sugar per cent.
No. 20 14 years tapped.	4-12-11	Jiran ...	500	1·064	57·0	13·95	0·20	14·15
	8-12-11	Jiran ...	900	1·058	51·2	12·60	0·33	12·99
	9-12-11	Dokat...	850	1·056	42·4	10·46	1·14	11·60
	16-12-11	Jiran ...	1,750	1·050	41·3	10·24	0·68	10·92
	17-12-11	Dokat ...	1,050	1·049	37·9	9·41	1·10	10·51
	24-12-11	Jiran ...	3,500	1·048	42·0	10·44	0·22	10 66
	25-12-11	Dokat ..	2,750	1·042	35·7	8·92	0 60	9·52
	28-12-11	Jiran ...	(3,400)	...	...	...	...	...
	29-12 11	Dokat ...	2,250	1·043	36·0	8·99	1·00	9·99
	30-12-11	Tekat ...	750	1 052	43·5	10·77	1·43	12·20
	2-1-12	Jiran ...	3,350	1·045	38·9	9 69	0 66	10·35
	3-1-12	Dokat ...	2,500	1·040	33 7	8·37	1·52	9·89
	7-1-12	Jiran ...	(3,700)	...	...	...	...	...
	8-1-12	Dokat ...	3,250	1·014	36 0	8·98	0·58	9·56
	9-1-12	Tekat ...	1,000	1·054	44·8	11·08	0·74	11·82
	12-1-12	Jiran ...	4,000	1·048	39·6	9·84	1·71	11·55
	13-1-12	Dokat ...	1,550	1·049	39·8	9·88	1 71	11·59
	17-1-12	Jiran ...	3,100	1·050	43·4	10·76	0·59	11·35
	18-1-12	Dokat ...	3,700	1·046	34·0	8·47	1·24	9·71
	19-1-12	Tekat ...	1,750	1·050	34·6	8·58	1 88	10 46
	23 1-12	Jiran ...	(3,100)	...	...	...	..	...
	24-1-12	Dokat ...	(3,000)	...	...	...	...	...
	25-1-12	Tekat ...	650	1·054	33·8	8·35	3 73	12·08
	28-1-12	Jiran ...	3,050	1·052	44·1	10·92	0·48	11·40
	29-1-12	Dokat ...	2,300	1·047	35·1	8·73	1·50	10·23
	30-1-12	Tekat ...	500	1·057	33·9	8·35	3·16	11·51
	2-2-12	Jiran ...	2,850	1·049	30·6	7·60	3·22	10·82
	3-2-12	Dokat ...	2,200	1·047	33·2	8·26	1·47	9 73
	7-2-12	Jiran ...	1,600	1·052	42·0	10·40	1·19	11·59
	8-2-12	Dokat ...	2,000	1·049	37·2	9 24	1·13	10·37

Total ... 66,850
= 70,190 gms.
= 154·77 lbs.

Notes on the tree.	Date.	Jiran, Dokat or Tekat.	Volume c.c.	Specific gravity.	Direct reading.	Sucrose per cent.	Reducing sugar per cent.	Total sugar per cent.
No. 3 3 years tapped.	4-12-11	Jiran ...	850	1·044	...	...	...	...
	8-12-11	,, ..	1,750	1·045	...	...	...	...
	9-12-11	Dokat ...	1,300	1·046	...	..	...	...
	16-12-11	Jiran ...	2,050	1·040	33·6	8·48	0·35	8·83
	17-12-11	Dokat ...	1,600	1·042	29·3	7·32	1·30	8·62
	24-12-11	Jiran ...	2,000	1·044	39·5	9 85	0 37	10·22
	25-12-11	Dokat ...	1,650	1·043	36·8	9·19	0 85	10·04
	28-12-11	Jiran ...	(2,250)	...	...	...	...	...
	29-12-11	Dokat ...	1,550	1·040	31·0	7·76	1·10	8·86
	30-12 11	Tekat ...	750	1·047	37·0	9·20	1·70	10 90
	2-1-12	Jiran ...	2,500	1·042	36·6	9·15	0 52	9·67
	3-1-12	Dokat ...	1,200	1·039	26·5	6·64	1·90	8·54
	7-1-12	Jiran ...	(2,350)	...	...	...	...	...
	8-1-12	Dokat ...	1,450	1·045	34·5	8·60	0·96	9·56
	12-1-12	Jiran ...	2,200	1·044	35·1	8·76	0·64	9·40
	13-1-12	Dokat ...	800	1·046	30·8	7 67	3·04	10·71
	17-1-12	Jiran ...	1,750	1·044	38 0	9·48	0·42	9 90
	18-1-12	Dokat ...	2,250	1·040	27·7	6·94	1·47	8·41
	19-1-12	Tekat ...	1,000	1·041	28·9	7·21	1·88	9·09
	22-1-12	Jiran ...	(1,750)	...	...	...	..	...
	23-1-12	Dokat ...	(1,000)	...	...	...	...	...
	24-1-12	Tekat ...	(500)	...	..	.	...	...
	28-1-12	Jiran ...	(1,625)	...	...	...	...	...
	29-1-12	Dokat ...	1,500	1·039	29·3	7·35	1·03	8·38
	30-1-12	Tekat ...	700	1·046	25·7	6·40	3·22	9 62
	2-2-12	Jiran ...	1,500	1·046	38·3	9 54	0·83	10·37
	3-2-12	Dokat ...	1,450	1·040	29·5	7·39	0·83	8·22
	7-2-12	Jiran ...	750	1·050	43·0	10·67	1·05	11·72
	8-2-12	Dokat ...	1,350	1·045	32·8	8·18	1·12	9·30

Total ... 44,325
= 46,275 gms.
= 102·04 lbs.

Trees Nos. 6 and 18 are omitted from the tables, as 6 was abandoned early in the season by the tappers, and only so few measurements of No. 18 were made that they could not form a really good guide as to the annual yield of the tree. Of the remaining 18 trees the average yield of juice per tree comes out at 101·15 lbs.

It must here be remembered that juice was only collected from these trees for the purpose of the experiment from December 4th till February 8th. The normal date sugar season however extends from about the second week in November till the first week in March.

In the period under experiment only about 28 collections of juice on an average were taken from each tree. A full tapping period would include about 45 collections of juice per tree. In order to calculate from our figures the yield of juice per tree per season one cannot simply multiply the figure found by 45/28 for the following reasons. In the first place, the yields during November and the later part of February are not so high as in December and January. Further, we must allow for rainy or cloudy weather which prevents collection of juice. Allowing for these facts, one may yet safely add 1/3 to the figures obtained above, in order to get the yield of juice per tree per season.

In this way we arrive at an average of juice per tree per season of 134·87 lbs.

The garden in which these 20 trees were situated is considered by the author to be distinctly below the average of the gardens in the district. This opinion has been formed as a result of about 2,000 individual measurements of trees throughout the district.

Measurements have been made also at Jessore town, Jhenidah, Kaliganj, Chowgachha and Tarpur, and in the villages for some miles around these centres and around Kotechandpur. These occasional measurements of individual trees cannot of course be used as a basis for calculating the annual yield of juice per tree. Around Jhenidah, the date cultivation is very poor and yields seem very low.

Near Jessore town the yields are larger than in other places, and in village Khartalar some very fine trees exist. This particular village was visited first on December 26th and 27th. In consequence of the high yields it was thought worth while visiting the garden again in early February.

The statement below shows the yields recorded by us in one particularly good plantation in this village in December and again in February. The outstanding features of this garden were the exceptional thickness of the trees, and the excellent cultivation. It seems that 300 lbs. of juice per tree per season might be expected in this garden, *i.e.*, $37\frac{1}{2}$ lbs. of gur.

The yields in all the other places mentioned appear to be much about the same.

In conclusion, the author considers that 170 lbs. of juice per tree per season may be taken as a fair average yield throughout the date sugar districts.

YIELDS OF DATE JUICE, KHARTALAR VILLAGE, JESSORE TOWN.

(Soil clayey and field well tilled. Trees 15′ × 15′.)

Date.	Years tapped.	Jiran, Dokat, or Tekat.	Volume c.c.	Specific gravity.
26th December 1911 ..	6	Jiran	600	1·066
	16	,,	4900	1·056
	16	,,	2750	1·061
	13	,,	2750	1·060
	15	,,	3400	1·056
	14	,,	4000	1·052
	12	,,	5500	1·053
	13	,,	1350	1·061
	13	,,	3350	1·062
	9	,,	2350	1·051
	13	,,	1100	1·070
	10	,,	3750	1·056
	12	,,	5750	1·056
	10	,,	2800	1·062
	13	,,	3650	1·056
	13	,,	2750	1·060
	13	,,	2350	1·060
	14	,,	5200	1·056

Date.	Years tapped.	Jiran, Dokat or Tekat.	Volume c. c.	Specific gravity.
27th December 1911..	4	Dokat	1750	1·042
	9	,,	900	1·052
	7	,,	2650	1·048
	11	,,	1100	1·067
	10	,,	2500	1·050
	12	,,	850	1·067
	6	,,	450	1·063
	14	,,	2500	1·060
	10	,,	1900	1·058
	13	,,	2250	1·053
	13	,,	2100	1·059
	13	,,	1950	1·059
	15	,,	800	1·060
	16	,,	1850	1·061
	13	,,	2200	1·057
	12	,,	3500	1·055
	16	,,	3250	1·054
	15	,,	3200	1·050
4th February 1912 ..	14	Jiran	4150	1·054
	12	,,	4500	1·050
	13	,,	3350	1·054
	15	,,	3000	1·050
	15	,,	2400	1·058
	15	,,	3750	1·046
	13	,,	2250	1·060
	15	,,	3100	1·050
	15	,,	2000	1·048
5th February 1912 ..	16	,,	6300	1.052
	10	,,	5500	1·054
	13	,,	6000	1·050
	10	,,	5250	1·053
	13	,,	4200	1·058
	11	,,	3000	1·061
	12	,,	1950	1·064
	7	,,	4200	1.054
	9	,,	3000	1·054
	4	,,	1650	1·055
	10	,,	2800	1·054
	13	,,	4750	1·054
	13	,,	3500	1·059
	15	Dokat	1750	1·060

Maximum daily yield of Juice per Tree.

The largest amount of juice observed from a single tree in one night was 6,600 c.c. or 15·25 lbs. near Kotechandpur. Other large yields were 14·30 lbs. near Kotechandpur and 14·61 lbs. at

Jessore. In order to get the total yield of juice in 24 hours one must add the amount of juice flowing during the day Measurements of this were not made, but it would probably be about 30 to 50% of the amount collected at night.

Variation in composition and yield of Juice at different periods during the Night.

We have already seen (p. 298) that jiran juice is of better quality than dokat juice, and further that commonly jiran juice is yielded in larger quantity than dokat. This in turn is better in quality than tekat juice and also its yield is much greater. It seemed of interest to determine if the yield of juice varied in its rate of flow and composition during a single night.

Accordingly during February 1911 certain trees were selected and their juice collected at various periods during the night, measured and analysed.

No. of trees.	Years tapped to date.	Jiran, Dokat or tekat.	Date of collection.	Period of collection.	Volume of juice c.c.	Sucrose gms. per 100 c.c.	Reducing sugars.
A	13	Jiran	16th Feb. 1911	5 to 6-15 P.M.	2075	17·75	1·04
		,,	16th ,, ,,	6-15 to 7-40 ,,	2075	13·95	0·65
		,,	16th ,, ,,	7-40 ,,	....	....	....
		,,	17th ,, ,,	5-30 A.M.	....	11·20	0·93
B	....	,,	16th ,, ,,	5 to 6-15 P.M.	....	15·50	0·53
				6-15 to 7-40 ,,	3700	13·90	0·34
		,,	16th ,, ,,	7-40 ,,	....	....	....
		,,	17th ,, ,,	5-30 A.M.	....	11·55	0·53
C	....	,,	18th ,, ,,	5 to 6-20 P.M.	500	14·50	1·25
		,,	18th ,, ,,	6-20 to 8-10 ,,	250	12·65	1·10
		,,	18th ,, ,,	8-10 ,,	....	....	....
		,,	19th ,, ,,	5-20 A.M.	1200	10·80	0·53
		,,	19th ,, ,,	5-20 ,,	200	9·20	0·65
				7 ,,	....	....	....
D	....	,,	18th ,, ,,	5 to 6-20 P.M.	500	13·45	1·05
		,,	18th ,, ,,	6-20 to 8-10 ,,	250	10·55	0·70
		,,	18th ,, ,,	8-10 ,,	....	....	....
		,,	19th ,, ,,	5-20 A.M.	1200	8·75	0·74
		,,	19th ,, ,,	5-20 to 7 ,,	200	7·50	0·63
5	12	Dokat	15th ,, ,,	5 to 6-30 P.M.	250	13·90	0·64
		,,	15th ,, ,,	6-30 ,,	....	....	....
		,,	16th ,, ,,	5-20 A.M.	3100	11·75	1·04
		,,	16th ,, ,,	5-20 ,,	....	....	....
				7-30 ,,	....	9·20	1·80
6	10	,,	15th ,, ,,	5 to 6-30 P.M.	200	11·63	1·28
		,,	15th ,, ,,	6-30 ,,	....	....	....
		,,	16th ,, ,,	5-20 A.M.	2100	8·70	1·73
		,,	16th ,, ,,	5-20 to 7-30 ,,	....	6·12	2·30

The tables shew that throughout the night there is a regular and rapid fall in the amount of cane-sugar in the juice. The reducing sugar has not shewn a corresponding increase. In fact in trees A, B, C and D yielding jiran juice, the reducing sugar has tended to decrease in proportion with the reduction of cane-sugar. In trees 5 and 6 yielding dokat juice, the amount of reducing sugar has increased to some extent with the decreasing content of cane-sugar.

It thus seems that the decrease in quality of the juice throughout the night is not entirely due to inversion, but the juice actually gets less and less concentrated.

In January and February 1912 the experiment was repeated on a single tree. This tree was in an isolated position being in an open space a good half mile from any other trees tapped for juice.

The only other differences between this and the above experiments were that in this case the juice was collected in an enamelled pot and further the tree had only been tapped on two or three occasions this season.

The cut surface was very clean in this case, and as will be seen a remarkably good juice was obtained. On the 17th and 18th January the juice collected contained only the merest trace of invert sugar certainly less than 0·05%.

Expt. No.	Date of collection.	Period of collection.	Volume of juice c.c.	Sucrose gms. per 100 c.c.	Reducing sugar.
1	17th January 1912 ..	4-30 to 6-15 P.M.	170	13·99	Trace.
	17th „ „ ..	6-30 to 8-15 „	160	13·86	„
	17th „ „ ..	8-35 to 10-30 „	175	14·02	„
	18th „ „ ..	10-45 P.M. to 6-30 A.M.	....	13·31	„
2	6th February 1912 ..	4-50 to 6-15 P.M.	160	13·62	0·50
	6th „ „ ..	6-25 to 7-45 „	190	13·81	0·55
	6th „ „ ..	7-55 to 9-30 „	160	13·60	0·58

This experiment does not show the same steady decline in richness and quality of the juice as the former experiments did.

CHART NO. 5.

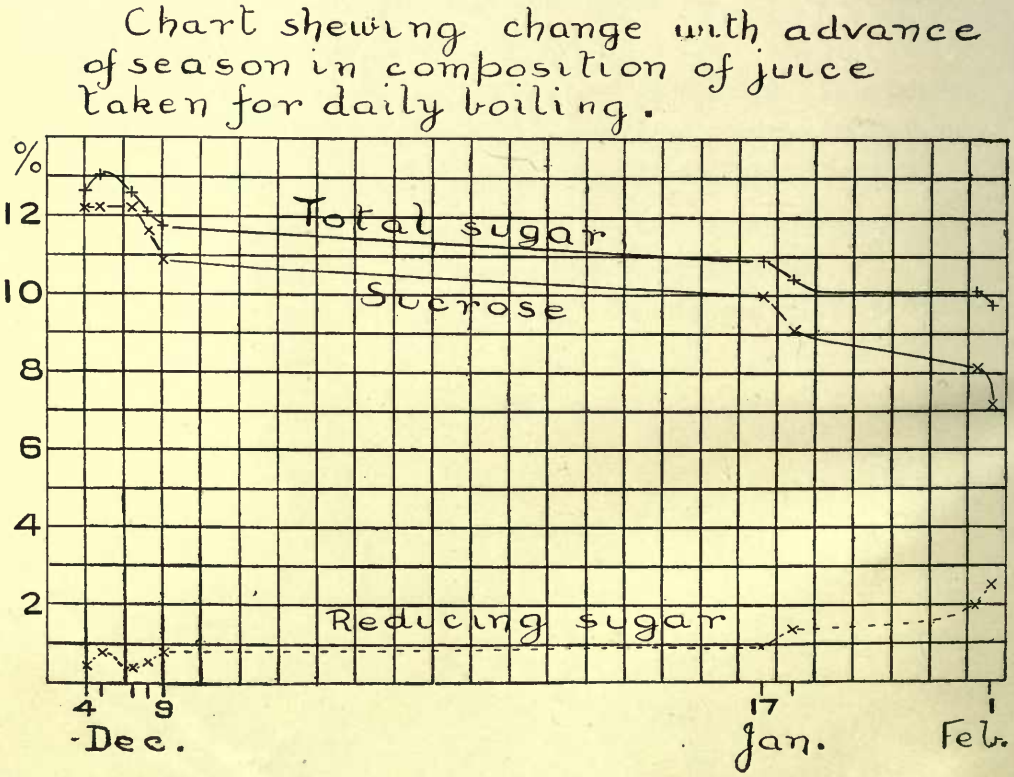


Chart shewing change with advance of season in composition of juice taken for daily boiling.
%
12
10
8
6
4
2
Total sugar
Sucrose
Reducing sugar
4
9
17
1
Dec.
Jan.
Feb.

Composition of the juice.

The tables and charts already given shew the analyses of a large number of juices. The connection between the amount of sugar in the juice and the yield of juice has already been referred to.

Throughout the season analyses have been made of the juice as it has been collected for the daily boilings. These analyses have been made at various places throughout the Jessore district and are collected together in the following table :—

Date.	Specific gravity.	Sucrose %.	Reducing sugar %.	Locality.
4th December 1911 ..	1·056	12·15	0·42	Garden No. 1, Kotechandpur.
5th „ „ ..	1·058	12·17	0·77	„ „ 1, „
6th „ „ ..	1·049	10·50	1·03	„ „ 2, „
7th „ „ ..	1·055	12·22	0·37	„ „ 1, „
7th „ „ ..	1·053	10·38	0·70	„ „ 2, „
8th „ „ ..	1·056	11·62	0·55	„ „ 1, „
9th „ „ ..	1·054	10·85	0·85	„ „ 1, „
11th „ „ ..	1·051	10·49	1·04	„ „ 2, „
19th „ „ ..	1·059	11·80	1·55	Chowgachha.
20th „ „ ..	1·060	11·65	1·43	„
22nd „ „ ..	1·053	11·16	0·69	Tarpur.
5th January 1912 ..	1·048	8·90	1·21	Jhenidah.
6th „ „ ..	1·049	9·87	1·03	Kaliganj.
16th „ „ ..	1·048	9·47	1·10	Sulemanpur.
16th „ „ ..	1·054	10·28	0·84	„
17th „ „ ..	1·047	9·96	0·90	Garden 1, Kotechandpur.
19th „ „ ..	1·047	9·06	1·32	„ „ „
21st „ „ ..	1·051	10·53	1·25	Maladharpur.
22nd „ „ ..	1·051	10·43	1·42	„
23rd „ „ ..	1·048	8·70	1·72	„
23rd „ „ ..	1·052	9·04	1·88	„
23rd „ „ ..	1·054	9·73	2·50	„
23rd „ „ ..	1·051	9·91	1·72	„
24th „ „ ..	1·053	10·51	2·80	Bidyadharpur.
24th „ „ ..	1·047	9·21	3·22	„
27th „ „ ..	1·054	10·90	1·02	Kotechandpur.
31st „ „ ..	1·047	8·11	1·97	Garden 1, Kotechandpur.
1st February „ ..	1·043	7·15	2·54	„ „ „

In garden No. 1 above it will be seen that analyses of the juice have been made at varying intervals throughout the season. In chart No. 5 these data are plotted in curves showing total sugar, sucrose and reducing sugar. These curves illustrate the excellent quality of the juice at the beginning of the season and shew how the glucose ratio rises as the season advances.

The table shows the results of the analysis of three different date juices side by side with an analysis of juice of red Mauritius cane grown at Pusa and analysed at the same time under the same conditions.

	A	D	E	Red Mauritius cane.
Sucrose	11·61	10·62	8·41	18·80
Reducing sugar	0·83	0·96	3·58	0·26
Ash	....	0·24	0·15	....
*Albuminoids	0·31	0·30	0·21	0·62
CO_2 as $NA_2\ CO_3$	0·14	0·65	0·00	0·00
Water	86·44	87·20	87·12	79·35
Undetermined	0·67	0·63	0·53	0·97
Total ..	100·00	100·00	100·00	100·00
Specific Gravity	1·0557	1·0524	1·0523	1·0880
* Containing total N.	0·05	0·048	0·034	0·099

The main constituent of the dry matter in date juice, as in the case of cane juice, is sugar. The amount of the nitrogenous constituents is smaller than in the cane juice examined, but 0·099% of nitrogen in cane juice is abnormally high. Duplicate determinations, however, were carried out. Geerligs[1] gives 0·036% of nitrogen as an average figure for cane juice and says that it varies from 0·018 to 0·062, so that there is not much difference between the nitrogen content of cane juice and date palm juice.

Mineral matter in juice.—Leather[2] found for cane juice that the mineral matter varied from 0·25 to 0·49. The ash of the date palm juice seems rather less in amount than this.

Pectin bodies.—These were determined by precipitating 50 c.c. of filtered juice with an equal volume of alcohol, filtering off on to a tared filter, and after washing with alcohol, drying to constant weight.

An analysis carried out in this way gave 0·26% of pectin. This precipitate of course would also include gum present in the juice.

[1] Cane sugar and the process of its manufacture in Java. H. C. Prinsen Geerligs, page 12

[2] Agricultural Ledger, 1896, No. 19, page 17.

Nitrogen in juice.—The following table gives an idea of the form in which the nitrogen occurs in date juice. The figures are expressed as grams nitrogen per 100 c. c. of juice :—

Juice.	Total N.	N. Pptd. by $Cu\ (OH)_2$	N as NH_3 and amide.	N as NH_3
A	0·050	0·017	0·008	0·002
D	0·051	0·017	0·008	....
E	0·035	....	....	....
F	0·052	0·017	0·010	0·002

The proportion of N precipitated by various reagents is noted below, the total nitrogen originally present being expressed as 100.

	Parts original Nitrogen.	Parts precipitated by basic lead acetate.	Precipitated by phosphotungstic acid.
Date palm juice	100	10·8	18
Juice of Red Mauritius cane ..	100	20·0	11·1

Lead was removed before precipitation with phosphotungstic acid and the liquid concentrated to half its bulk.

Methods of Analysis.

Specific Gravity.—This was determined by means of the Westphal balance at Pusa and by hydrometer in camp.

Sucrose.—The juice was first clarified with dry basic lead acetate and the excess of lead removed with sodium phosphate. Readings were then taken in a Schmidt-Haensch ordinary light polariscope before and after inversion. The number of grams sucrose per 100 c.c. was found by the formula :—

$$\frac{(a-b) \times 26{\cdot}048}{143 - \dfrac{t}{2}}$$

where a equals direct reading.
b ,, invert reading.
t ,, temperature of the readings in °C.

Invert sugar.—For this the method of Brown, Morris and Miller was followed at Pusa.[1] The Cu_2O was estimated, however, by solution in a sulphuric acid solution of ferric sulphate. An amount of iron is reduced corresponding to that of the Cu_2O. The amount of ferric reduction was determined by titration with potassium permanganate whose strength was known in terms of CuO. The percentage of invert sugar was then calculated from the tables in the paper quoted.

The method was checked by preparing a solution of invert sugar of known strength by inverting pure cane-sugar. The solution was then diluted to 10 times its bulk and then contained in 10 c.c. 0·0975 gm. invert sugar. The invert sugar was then estimated in the solution by the method outlined above. Triplicate determinations were made, using 10 c.c. of the dilute sugar solution.

$KMnO_4$ used	c.c.
(1)	23·45
(2)	23·55
(3)	23·50
Average	23·50
less blank determination	0·55
	22·95

1 c.c. $KMnO_4$ was equivalent to	0·01032 gm. CuO.	
∴ 22·95 „ is „ ..	0·2368 „ „	

By the tables :—

0·2368 gm. CuO equals	·0973 gm. invert sugar.
actually present	·0975.

The method has frequently been checked, with equally good results. In camp the reducing sugar was determined by direct titration of the juice after clarification, against the copper solution.

Total solids.—A platinum basin containing cleaned pieces of pumice was brought to a constant weight, 10 c.c. of the juice was then run in and dried to a constant weight.

Total nitrogen.—This was determined by the Kjeldahl method using 25 c.c. of the juice.

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[1] J. C. S. Trans. 1897, page 278, et seq.

Ammoniacal nitrogen.—This was determined by the Sachsse-Schloesing-Longi method by distillation of the juice with magnesia at a pressure of 10—15 mm. and at a temperature of 35—40°C.[1]

Amide and ammoniacal nitrogen.—For this the juice was heated in the water bath for 6 hours with dilute HCl to hydrolise the amides. The ammonia was estimated by distillation as in the case of the ammoniacal nitrogen estimation.

Albuminoid nitrogen.—This was estimated by Stutzer's method, that is, precipitation with copper hydrate and then estimating the nitrogen in the precipitate by the Kjeldahl method.

Factors influencing yield and composition of the Juice.

The data given in the tables on pages 322-23, have in the case of four trees been plotted in curves (Charts 1 to 4), showing at a glance the yield of juice as the season advances. A reference to the curves brings out the interesting fact that they are of a similar type for all the trees. For each tree the jiran, dokat and tekat yields have been represented by separate curves. In general the yield is smallest at the beginning of the season (*Cf.* curves, p. 7, Studies of maple sap, by Morse, Bull. No. 32, New Hamps. Coll.). It gradually increases to its maximum at about the third week in January and then falls away again fairly rapidly till the end of the season.

Effect of climatic conditions. (a) Humidity.—An attempt was made to see if changes in the amount of moisture in the air affected the yield of juice, but no useful results were obtained.

(b) Temperature.—It is agreed throughout the date sugar districts, that the colder the nights, the richer and the more plentiful is the juice.

Newlands[2] records that in the case of the maple tree the best yields of juice are obtained during cold clear nights following bright warm days.

[1] Trans. Guinness Research Lab., Vol. 1, Pt. 1 (1903).

[2] Handbook for Sugar Planters, Newlands.

During our experiments careful observation was kept of the daily maximum and minimum temperatures. The records of temperature are unfortunately not complete owing to continual absences on tour from Kotechandpur.

The charts shew that the yields are greatest during the coldest months of the year. Sudden changes in temperature seem to have very marked effects on the yield of juice. Thus on January 7th the temperature was very low. The yield of juice immediately after that date rose rapidly, though it is to be noticed that the effect of a cold night is not always seen that same night in an increased yield of juice. This increase comes the following night as a rule.

Rise of temperature results in immediately reducing the quantity of juice. This is well seen in the curves. From January 10th to 15th the night temperature rose rapidly. A sudden fall in yield is shewn in all the curves. From January 15th to 17th the night temperatures rapidly decreased. Most of the yield curves shew a corresponding rise in accordance with this. Towards the end of the season the yields of juice are too small to shew any marked variation corresponding to changes in temperature.

The writer suggests that during cold weather little growth of new leaves or flowers takes place in the tree and hence the colder the weather the more sap there is available to flow to the cut surface. Directly the temperature rises, growth goes on more rapidly and the supply of sap is diverted from the cut surface to the growing points.

With regard to the amount of sugar in the juice the curves give us interesting information. In all of them is to be seen a distinct connection between the yield of juice and its sugar content. As a general rule the smallest yields are the richest in sugar. Fischer[1] reports that when bleeding is active, the sap becomes gradually poorer and poorer in sugar.

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[1] Pfeiffer's Physiology of Plants, Ewart, Vol. 1.

Since writing this the author finds that a similar phenomenon has been noticed in the case of the maple tree in America (see Studies of Maple sap by Morse, Bull. No. 32, September 1895, New Hampshire College, Agric. Expt. Statn., page 4).

When, following a cold night a large yield of juice is obtained, there is an accompanying decrease in sugar concentration. As a consequence of this we see from the charts that whereas the curve for yield throughout the season is concave with regard to the base line of the chart, the curve for sugar content of the juice is convex. In other words, at the beginning and end of the season we have the lowest yields of juice, but at these times it is most concentrated.

In the middle of the season with the highest yields of juice we have the lowest concentrations of sugar.

The 'tekat' curves of trees Nos. 3 and 20 and the dokat curves of No. 11 are particularly good illustrations of this connection between yield of juice and its sugar concentration. Further it is to be noted that tekat juice is richer than jiran or dokat in sugar, but that its yield is much smaller.

(*c*) Cloudy, rainy or misty weather.—These weather conditions always affect the yield adversely. This is probably due to the fact that in these kinds of weather the night temperature is relatively high, but of course the high humidity might also have an effect in stopping bleeding. From the 12th to the 15th of January and the 31st of January to 8th February the weather was cloudy. From the charts it is seen that these dates correspond to rises in the night temperature.

Jiran versus *dokat and tekat juices.*—It is well recognised that dokat juice is much less in quantity than the corresponding jiran. The yield from tekat juice is much less still. The curves shew up these points very well. Towards the end of the season, however, the yield of dokat juice is frequently seen to surpass the jiran yields. (See charts for trees Nos. 3, 11 and 20.) This is explained by the fact that it is a common practice towards the end of the season to cut the tree both for jiran and dokat. Dokat juice obtained from a freshly cut surface is called *dokat-pocha.*

With regard to the amount of sugar in the juice dokat is supposed to be worse than jiran and tekat, much worse than either of these. Here it is perhaps in place to observe that a high yielding tree need not necessarily give a juice poor in sugar. High yield of juice, rich in

sugar, is frequently met with, and the trees at Khartalar, Jessore, are good illustrations of this. The trees were very heavy yielders, but the specific gravity shows the juice to be very concentrated.

The curves shew that very generally the sugar concentration is much lower in dokat than in jiran juice. The dokat curves for sugar concentration are seen in places to reach above the jiran curves, but wherever this is the case it corresponds to a low yield of juice, and, as we have seen, the amount of sugar in the juice of a particular tree depends largely on the amount of the juice-flow.

The tekat curves on the other hand shew that tekat juice is much more concentrated than either jiran or dokat. This is no doubt due to the small yield of juice. At the same time reference to the tables at pp. 322-23 for trees Nos. 3, 11, 16, and 20 shews that though tekat juice is rich in sugar a large proportion of this consists of reducing sugar. This is only natural, as after the juice has flowed from the cut surface for three days this surface has become very dirty and much yeast has grown on it. So that we should expect much fermentation to go on in the tekat juice.

Similarly for the same reason the proportion of reducing sugar in dokat juice is much higher than in jiran juice. One can see this on pp. 322-23 where the tables for trees Nos. 3, 11, 16 and 20 are given.

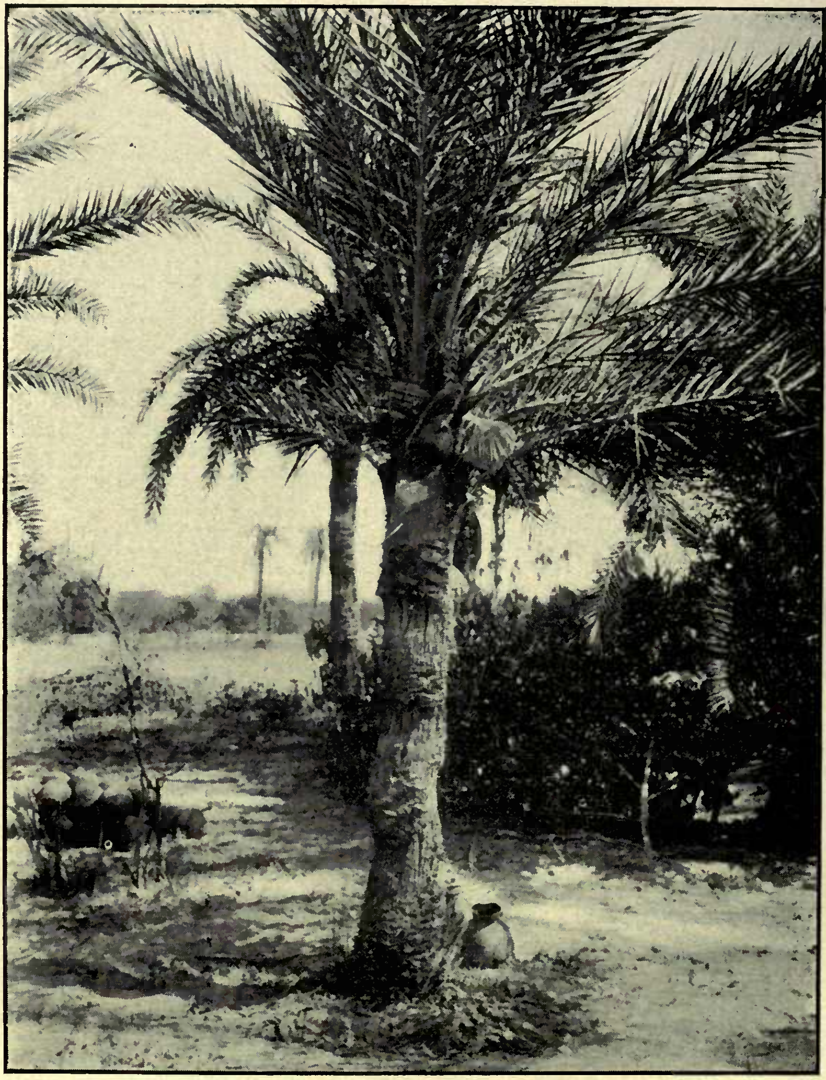
In our experiments the following are the extremes between which the amounts of sucrose and invert sugar have varied in jiran, dokat and tekat juice :—

	Sucrose.	Invert sugar.
Jiran	15·31 — 6·19	trace — 3·80
Dokat	14·01 — 4·37	trace — 3·80
Tekat	11·08 — 4·95	0·74 — 4·60

Cultivation.—The best cultivated gardens have generally been observed to give the best yields. The excellent garden at Khartalar (p. 325) is a very well cultivated one. Cultivation encourages a larger and more healthy growth of the tree.

[1] See Table on pages 325-26.

PLATE V.



Male tree.—The male inflorescence occurs as large loose bunches. The tree above has several such bunches and one is particularly well seen in the photograph.

Thickness of tree.—Careful note has been kept throughout the work of the relation of the yield to the thickness of the stem. It has always been found that thick stemmed plants give the highest yields.

Amount of foliage.—No definite relation has been established between this factor and the yield and composition of juice. Indications have been observed which tend to shew that trees with plentiful foliage give high yields. This fact is well recognised in the case of the sugar maple. Excessive stripping of the leaves for fuel and fodder should be discouraged as it is in the leaves that the sugar has its origin.

Healthiness of tree.—Trees have frequently been met with whose trunks have almost entirely rotted away near the base leaving simply a thin arch to support the trees. Strange to say these trees seem to give a very satisfactory yield.

Effect of soil.—The natives say that in sandy soils the yield and quality of juice are poorer than on heavier soils. This could not be determined by the author as it would require a separate enquiry of its own. All that can be said is that certain indications have been obtained which support the native saying. In this connection the reader is referred to the statement on p. 325 relating to the yields of juice at Khartalar. It will be seen that on this clay loam heavy yields were obtained of a uniformly rich juice.

Effect of flowering.—It has been stated that during flowering the quality of the juice falls off. N. N. Banerjee[1] states that the male trees yield sap early in the season and that the female tree yields its sap later on. These phenomena have not been noticed by us, although careful attention was paid to these points.

Individuality of the tree.—It has been continually observed by us that high yielding capacity of juice is a fairly constant character. This can be well seen by reference to the tables on pp. 308 to 323. A tree which is normally a low yielder such as No. 4 gives low yields

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[1] Bengal Agri. Dept.'s Quarterly Journal, 1907, page 164.

throughout the season. Trees Nos. 2, 8, 10, 15, 17 and 19 are also obviously constantly low yielders. On the other hand, trees Nos. 5, 7, 9, 11, 16 and 20 give relatively constantly high yields.

Age of tree.—It is difficult from our figures to trace any direct connection between the age of the tree and the yield or composition of juice. Indeed, several years' work would be necessary in order to decide the question. It is generally stated that trees do not give their full yield until they are about 7 or 8 years old. Thus Robinson writes that if the trees are cut for the first time in their 6th year of growth then the yield of juice per tree is about $\frac{1}{2}$ the yield of juice of a tree of full maturity.

In the 7th year of growth the yield is about $\frac{3}{4}$ths and in the 8th year of growth the full yield is obtained.

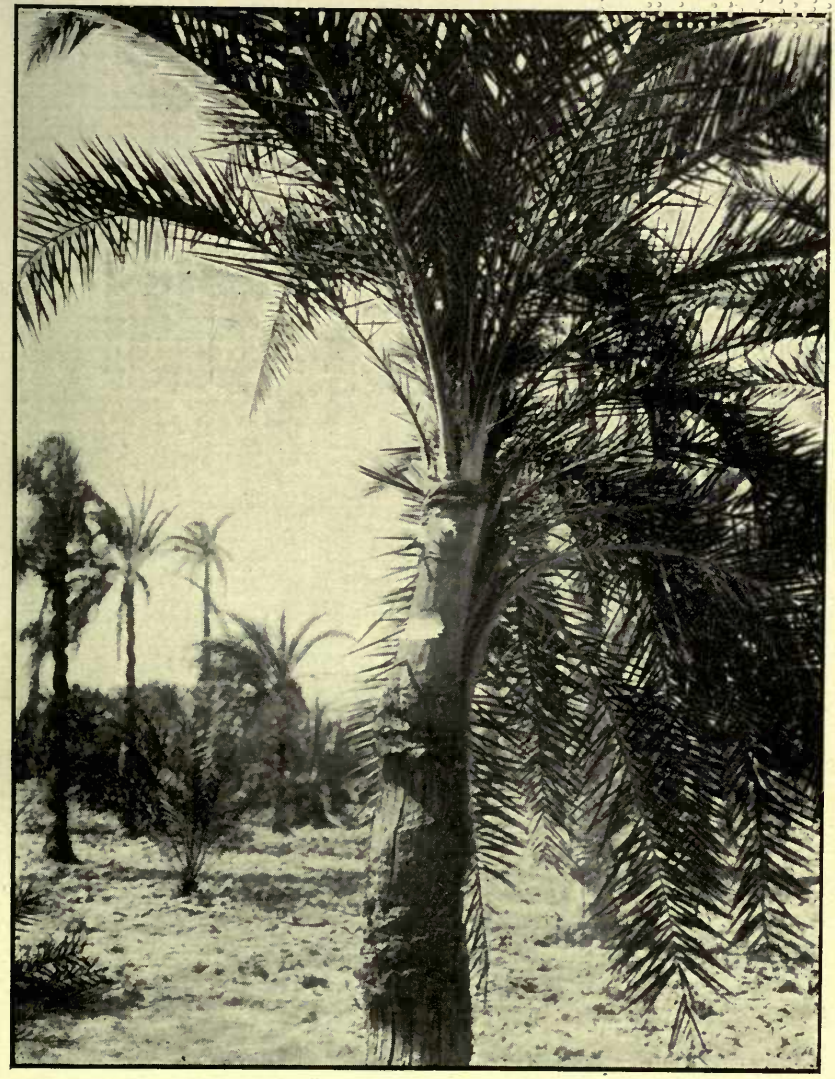
In our experiments tree No. 16 which was only in its first year of cutting gave a fairly high yield. Trees which have been tapped for 36 successive years are still giving a good flow of juice.

Amount of inversion going on in the juice during the night.

The collecting pots are attached to the trees at any time after : P.M., according to the nature of the weather. They are collected at any time after 6 next morning but many are not collected till 7 or 8 o'clock. So that much of the juice is exposed to the air 12—15 hours. In this time a certain amount of inversion might be expected to go on. To get an idea of how great the loss from this source might be the following experiments were made in February 1911.

A large quantity of juice was collected in the evening and several pots were about half filled with it and then hung up on trees again, trees of course which were not giving juice. The juice in each pot was analysed over night and again next morning. The results are shewn :—

PLATE VI.



Female tree.—The female inflorescence is slender and close. Careful observation of the photograph shews the tree to be in full flower. The inflorescences appear berry-like among the leaf stalks in the photograph.

Expt. No.	Date.	Time of collection.	Sucrose gms. per 100 c.c.	Reducing sugar gms. per 100 c.c.	% sucrose inverted.	Minimum night temperature °F.
1	15th February 1911 ..	6-30 p.m.	13·90	0·64	....	53
	16th ,, ,, ..	5-20 a.m.	11·75	1·04	15·47	....
	16th ,, ,, ..	7-30 ,,	9·20	1·80	33·67	....
2	15th ,, ,, ..	6-30 p.m.	11·63	1·28	....	....
	16th ,, ,, ..	5-20 a.m.	8·70	1·73	25·20	53
	16th ,, ,, ..	7-30 ,,	6·12	2·30	47·4	....
3(1)	17th ,, ,, ..	7 p.m.	11·65	1·25	....	55
	18th ,, ,, ..	7-45 a.m.	6·60	4·86	43·4	....
4(1)	17th ,, ,, ..	7 p.m.	13·30	2·20	....	....
	18th ,, ,, ..	7 45 a.m.	7·10	6·92	46·6	55
5(1)	17th ,, ,, ..	7 p.m.	13·40	1·19	....	....
	18th ,, ,, ..	7-45 a.m.	7·02	4·40	47·6	55
6	17th ,, ,, ..	7-45 p.m.	13·95	0·65	....	....
	18th ,, ,, ..	7 a.m.	12·25	2·87	12·2	55
7	17th ,, ,, ..	7-40 p.m.	13·90	0·34	....	....
	18th ,, ,, ..	7 a.m.	12·96	1.28	6·7	55
8	18th ,, ,, ..	8-10 p.m.	12·65	1·10	....	....
	19th ,, ,, ..	7 a.m.	6·00	5·40	52.6	56
9	18th ,, ,, ..	8-10 p.m.	10·55	0·70	....	....
	19th ,, ,, ..	7 a.m.	9·00	2·87	14·7	56
10	26th ,, ,, ..	7-30 p.m.	15.44	0.57	....	....
	27th ,, ,, ..	8 a.m.	14·77	1·47	4·34	....
	27th ,, ,, ..	8 a.m.	14·18	1·94	8·16	....
11	27th ,, ,, ..	9 p.m.	13·22	0·75	....	....
	28th ,, ,, .	7-30 a.m.	[10·72	2·87	18·91	....
	28th ,, ,, ..	7-30 a.m.	10-80	3·24	18·31	....
12	28th ,, ,, ..	8-30 p.m.	11.75	0·97	....	....
	1st March 1911 ..	8 a.m.	7·48	4·04	36·4	....
	1st ,, ,, ..	8 a.m.	7·02	4·40	40·2	....
13	19th February 1911 ..	5-20 a.m.	10·80	0·53	....	56
	19th ,, ,, ..	7 a.m.	10·74	0·57	0·56	....
14	19th ,, ,, ..	5-20 a.m.	8·80	0·73	....	....
	19th ,, ,, ..	7 a.m.	8·70	0·81	1·1	56
15	16th ,, ,, ..	5-20 a.m.	10·65	1·47	....	53
	16th ,, ,, ..	7 a.m.	10·36	1·80	2·7	....

1 Mouths of pots covered tightly with cloths and hence juice warm (18° C.) This probably explains high amount of inversion.

A glance at the figures shews that the amount of inversion going on is large, varying from 0·6 to 53 per cent. Experiments 10, 11 and 12 were duplicated, and it is seen that the duplicates agree very well indeed. A few results are given shewing the amount of inversion going on after 5-30 A.M., as it appeared to the writer that much loss by inversion might be saved if the pots were collected by that hour; the present practice being to collect the juice much later. Experiments Nos. 1 and 2 shew the loss by inversion between 5-30 A.M. and 7 A.M., to be considerable, namely, 18·2 per cent. and 22·2 per cent., respectively.

On the other hand, experiments 13, 14 and 15 shew the loss during this period to be almost inappreciable. The difference in these results is explained by the fact that the juice used in experiments 1 and 2 was juice which had been standing in the pot overnight. It was, therefore, in full process of inversion and probably fairly warm. In experiments Nos. 13, 14 and 15 the juice used for the experiment was collecting in the pot from 8-30 P.M. to 5-20 A.M. and, therefore, it was not probably in full process of inversion and also it was probably much colder.

This fact also applies to all these experiments on inversion. The figures given shew the maximum inversion which can take place. In practice, the juice is running all night, and of course the later runnings are not exposed in the pot for anything like the length of time that the juice was which was used in these experiments.

Effect of Preservatives on the Juice.

A camp laboratory does not afford an opportunity for a very complete examination of date juice. Accordingly some 12 litres of good juice were collected and treated with various preservatives in order to keep them until arrival at Pusa. The following table shews the preservative used, the volume of juice and the direct reading of the solution in a Schmidt-Hænsch polariscope from time to time.

No. of Experiment.	Preservative.	Vol. of juice c.c.	Date.	Direct reading.	REMARKS.
				about	
I	Ether 80 c.c.	2,000	10th Feb. 1912	40·0	Jiran juice.
			11th ,, ,,	27·4	....
			12th ,, ,,	18·0	....
			Liquid still clear, but gaseous and smelt of alcohol.		
II	Formalin 3 c.c. of 40 %.	700	8th Feb. 1912	47·9	Jiran.
			11th ,, ,,	47·9	(Filtered juice).
			12th ,, ,,	47·9	Bottle almost completely filled.
			13th ,, ,,	47·9	....
			17th ,, ,,	46·7	....
			20th ,, ,,	45·5	Free from alcohol.
III	Formalin 15 c.c.	2,500	11th ,, ,,	40·3	Jiran (strained through cloth).
			20th ,, ,,	21·4	Free from alcohol.
IV	,, 10 ,,	1,650	12th ,, ,,	48·75	Jiran (filtered).
			20th ,, ,,	44·00	....
V	,, 10 ,,	1,600	13th ,, ,,	46·0	Dokat.
			17th ,, ,,	42·3	(Strained through cloth).
			20th ,, ,,	40·3	Free from alcohol.
VI	,, 15 ,,	2,500	12th ,, ,,	44·9	Jiran.
			17th ,, ,,	30·7	....
			20th ,, ,,	25·5	No alcohol.
VII	Dry basic lead acetate 4 gms.	2,000	10th ,, ,,	38·3	Jiran.
			11th ,, ,,	35·6	....
			12th ,, ,,	32·2	Gaseous and some alcohol.
			Not enough lead acetate added		
VIII	Dry basic lead acetate 8 gms.	1,800	11th Feb. 1912	39·0	Jiran.
			12th ,, ,,	39·0	....
			20th ,, ,,	34·1	....
			No alcohol produced.		
IX	Mercuric chloride 5 gms.	2,000	10th Feb. 1912	38·7	Jiran.
			11th ,, ,,	38·7	....
			12th ,, ,,	38·7	....
			20th ,, ,,	38·4	....
			22nd ,, ,,	37·8	....
			No alcohol produced.		
X	Do. 5 gms.	2,200	12th Feb. 1912	49·9	Jiran.
			20th ,, ,,	42·1	....

As seen above, the juices were mainly collected on the 10th, 11th and 12th February and Pusa was reached on the 16th. Work on the juices was started at once so that most of them were in a fit state for further examination. Nos. I and VII were discarded altogether and No. III only used for the preparation of ash for analysis.

Formalin.—This seems to be very satisfactory. It was noted that formalin had more marked effects when the juice was first filtered through filter paper, than when it was simply strained through cloth. Thus in No. II the juice kept in a remarkable manner with no sign of change for 12 days and only 3 c.c. of·40 per cent. formalin were added to 700 c.c. of juice. It might be remarked here that formalin was observed to bleach the faint brownish colouration which a quite fresh date juice has. The other four experiments with formalin did not give as great an effect but the formalin seems to have checked the alcoholic fermentation only allowing the inversion of the sucrose.

Dry basic lead acetate in experiment No. VIII seems to have kept juice fairly well for some days; but we should have doubtless obtained much better results had we filtered off the lead precipitate. It was unfortunate that the juice could not be examined for some days after the 12th owing to travelling. Dry basic lead acetate has been previously recommended for use in storing juices. In a series of experiments described by Spencer[1] a sample of cane juice preserved with this reagent gave the following percentages of sucrose after successive intervals of 24 hours except where otherwise stated: 16·98, 16·96, 16·98, 16·96, 16·98, 16·98 (interval 48 hours), 16·98 (interval 48 hours), 16·96; after a further interval of 5 days there were indications of fermentation.

Our experiments are not so favourable to the use of dry basic lead acetate, but it is possible we did not use a sufficiency of the reagent. It might be of interest here to mention that on several occasions in camp juices which had been clarified with basic lead acetate and analysed one day were found unchanged on analysis the following day. Thus one may take samples of juice in the field and add dry basic lead acetate on the spot and there need be no fear of their undergoing change if one is delayed by an hour or two in carrying out the analysis.

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[1] Handbook for Sugar Manufacturers, p. 85.

Mercuric chloride.—The experiments shew this to be a very effective preservative. By an oversight however much larger amounts of the substance were used than are really required.

Acids present in Date Juice.

About 6 litres of preserved juice free from fermentation were distilled in steam after acidifying with 0·5 per cent. of sulphuric acid. About 4 litres of distillate were collected. The distillate was practically neutral and was not further examined. The residual liquid in the flask was extracted with ether in a large separating funnel. About 15 c.c. of the liquid was shaken with about 200 c.c. of ether at each extraction until all the liquid had been so treated. The whole process of extraction was gone through in a similar way with a fresh lot of ether. The ether extracts were then combined and the ether distilled off. About one half of a c.c. of a tarry liquid of a very bitter taste was left behind together with 7 or 8 small clusters of crystals. Attempts to purify the crystals failed as they were present in such small quantity—only a few milligrams at the most. They were readily soluble in water and alcohol, and had an acid reaction and a cooling sharp taste. On examination under a microscope fitted with a polarising apparatus the crystals were seen to be needle-shaped and gave interference bands on rotating the Nicols, the play of colours being very brilliant. Crystals of malic acid appeared to be of the same crystalline form and behaved in a similar manner under polarised light. Only one form of crystal was observed. On solution in water and addition of neutral lead acetate a curdy precipitate was obtained.

Attempts to recover the free acid by decomposition of the lead salt with hydrogen sulphide failed.

Cause of alkalinity of the juice.

It has already been stated that date palm juices when first drawn from the tree are alkaline to litmus paper.[1] The quite fresh

[1] The sap of the Buri palm (Corypha elata) has been shewn to be alkaline when freshly drawn. (See Gibbs "The Alcohol Industry," Part I, Philippine Jour, of Science, June 1911, Series A, p. 176.)

unfermented juices are quite strongly alkaline to litmus and to methyl-orange. A juice tested at Pusa which was still alkaline to litmus and methyl-orange was found to be acid to phenolphtalein, but this was the only juice which we had an opportunity of examining with phenolphtalein.

Fresh juices always give a small amount of effervescence on adding acid to them.

Some juices were titrated with sulphuric acid using litmus as indicator.

The following amounts of alkalinity reckoned as gms. Na_2CO_3 per 100 c.c. of juice were obtained.

Tree in compound	0·092
„ No. 20	0·025
„ „ 3	0·05
Average sample for daily boiling..	0·012

It seemed probable that the alkalinity of the juices was due to alkaline carbonates.

At Pusa some determinations of free and combined CO_2 in two date juices which were still alkaline were carried out gravimetrically, 50 c.c. of the juice was first boiled and CO_2 evolved collected in weighed soda lime tubes. Dilute hydrochloric acid was then added and any liberated CO_2 was collected in weighed soda lime tubes, the liquid being boiled towards the end of the process.

The figures below show the amount of (*a*) free and (*b*) combined CO_2 present in the juices expressed as grams Na_2CO_3 per 100 grams of juice.

	Gms. per 100 gms.	
	Free CO_2 calculated as Na_2CO_3	Combined CO_2 calculated as Na_2CO_3
Juice A	0·0019	0·14
„ D	0·052	0·047

These amounts are quite sufficient to account for the marked alkalinity of the juice. At the same time it must be remembered

that if basic nitrogenous compounds are present they also would have an alkaline reaction.

Juice A was known to be practically free from fermentation and the small amount of free CO_2 proves this. It corresponds to juice II (see page 341 of this memoir). CO_2 determinations were carried out on 18th February 1912, when the direct reading shewed but little change.

Juice D corresponds to juice V on that page, and it is seen that more change has gone on than in the case of juice A, and hence the amount of carbonate would be expected to be less. The amount of free CO_2 present points to fermentation.

The Sugars of the Palm.

An enquiry into the kinds of sugars in the wild date palm does not appear to have been made. It has been assumed that they are the same as those occurring in the cane. It appeared desirable to make a thorough examination of the sugars present in order to see whether or no this is the case.

In the first place, experiments in the field shew that cane sugar is the only sugar normally present in the sap as it runs from the tree. By keeping the surface of a tree specially clean only the merest trace of reducing sugar has been found in the juice certainly less than 0·01 per cent.

About 100 gms. of mixed Gnour and Akrah sugars were dissolved in hot 80 per cent. alcohol and filtered. The filtered solution was agitated for about an hour and then allowed to stand. After 2 days numbers of fine crystals had formed, apparently cane sugar. The crystals were dissolved in as small as possible a quantity of distilled water and an excess of absolute alcohol added and again thoroughly shaken for an hour. In a couple of days crystals had again formed.

Some cane sugar, Cossipore 2nd white, was once recrystallised by the same method. Both sugars were dried at 100°C and examined as follows :—

Rotatory power.—6·512 gms. were dissolved in water and made up to 50 c.c. The solution was then read in a Schmidt and Hænsch Saccharimeter. The following readings were obtained :—

		= Sucrose.
Sugar from date palm	49·9	99·80
Cane sugar	49·7	99·60
Theory for pure cane sugar	50·0	100·00

The solutions were then inverted by adding 1/10 of their volume of hydrochloric acid and heating to 68° C. in 15 minutes.

The invert readings uncorrected for dilution were :—

Sugar from date palm	12·6 (t = 30° C.)
Cane sugar	12·6 (t = 30° C.)

Melting point.—The melting points of the above two sugars and of some Tate's cube sugar were determined under exactly similar conditions. The following results corrected, were obtained :—

Sugar from date palm	181° C.
Cane sugar (as above)	182° C.
Tate's cube sugar	182° C.

It may be mentioned that the melting point of sucrose is given in all text-books as 160—161° C. Beilstein also gives 160, but mentions that 180 was found by Péligot. Under no circumstances were we able to get sucrose to melt at 160—161°, and this statement of the melting point of sucrose in text-books needs correction.

The sugar separated from the date palm is therefore shewn to be sucrose as in the case of cane sugar.

Fifty gms. of date gur were dissolved in water. A determination of the amount of reducing sugar present was made, and this amounted to about 7 per cent.

To the above a solution of phenyl hydrazin acetate was added containing 12 gms. phenyl hydrazin, 12 gms. of glacial acetic acid and 30 c.c. of water. The liquid was heated inside a water bath for 2½ hours. An osazone began to separate after 25—30 minutes. The crystals were filtered off at the pump and washed with water and then alcohol and dried. The weight of the crude osazone was about 10 gms.

About 5 gms. of the osazone were completely dissolved in as small a quantity of boiling alcohol as possible, filtered through a hot funnel and allowed to crystallise. The crystals were washed with water and alcohol at the pump and dried.

The mother liquor was evaporated down, filtered through a hot funnel, allowed to cool and crystallise. The crystals were then washed with water and alcohol as before. By repeating this process four crops of crystals were obtained in all. Each crop was then examined :—(*a*) for its melting point, (*b*) microscopically.

(*a*) *Melting point corrected.*—For this determination it is essential that the process of heating be carried out very rapidly and exactly in the same manner in each test. In these tests the temperature was raised from 190 to the melting point in $2\frac{1}{2}$—3 minutes :—

Crop I	206	Crop III	206
„ II	206	„ IV	205·5

(*b*) *Microscopic Examination.*—This revealed in all cases a mass of needle-shaped crystals arranged in the characteristic bundles into which glucosazone collects. Only one form of crystal could be observed.

Glucosazone was now prepared by inverting some pure cane sugar and forming the osazone as above. On recrystallisation from alcohol its melting point was found to be 206 (corrected). Its microscopical appearance was exactly like that of the osazone obtained above.

Some of the osazone from date gur was next finely ground with the pure glucosazone. The melting point of the mixture corrected was 206.

The above experiment on the formation of osazones from date gur was repeated and also carried out with raw date sugars and with some of the juices which had been treated with preservative and brought to Pusa. The osazone obtained always had the same properties.

Hence the only osazone formed is glucosazone.

Glucosazone is formed by glucose, levulose or mannose. Hence the only sugars which can be present in the date juice are cane sugar, glucose, levulose and perhaps mannose.

Mannose was tested for in the following[1] way :—

10 gms. of Akrah sugar were dissolved in 25 c.c. of water, clarified with a pinch of anhydrous basic lead acetate and filtered. The lead was separated by means of sodium phosphate and the solution again filtered. One per cent. of its volume of glacial acetic acid was now added and the volume made up to 75 c.c. ; 5 c.c. of phenyl hydrazin, 5 c.c. of glacial acetic acid, and 12 c.c. of water were now added. The mixture was then well agitated for half an hour and left for 24 hours. Three tests were carried out but in none was the hydrazone of mannose formed.

We must conclude then that the sugars normally present in the juice of the date palm are the same as those which occur in the sugar-cane.

Composition of Date Juice Ash.

About one gram of ash was prepared by concentrating the juice and igniting the residue. A pure white ash was thus obtained. It had the following composition :—

	Per cent.
K_2O	55·08
Na_2O	7·85
CaO	0·48
MgO	2·51
Co_2	13·30
Cl_2	12·89
So_3	4·64
P_2O_5	1·57
Insol. silica	0·82
Soluble silica	0·86

It is to be noted that the ash is very rich in potash and that it also contains a rather high proportion of chlorine.

[1] Bull. de l'Assoc. des Chim. de Sucr, et de dist., 1901, 18 (10), 758-69.

PLATE VII.

Boiling down the juice.—On the right is the rack on which the boiling pans are placed from day to day, the fuel—rahar stalks and palm leaves—is seen piled in background.

PART VIII.

Manufacture.

Boiling.

The boiling apparatus called the *bain* is prepared in the shade of a tree and commonly surrounded by a fence of date palm leaves. It generally consists of a hole of about 3 ft. in diameter sunk about 2 ft. in the ground over which are supported by mud arches,[1] four thin earthen pans of a semi-globular shape (see plate VII) and 18″ in diameter. One *bain* may contain however as many as 16 pans or as few as 2. The hole itself is the furnace and has two apertures on opposite sides for feeding in the fuel and for the escape of the smoke. The juice is poured into the pans and the fire is lit and the boiling continued for 3—4 hours until the liquid is of the right density. Small amounts of scum are removed from time to time, but the amount of this is much less than in cane juice, being almost negligible. Dried date leaves are laid over the surface of the pan to allay the frothing. The bubbles which appear in the pans mark the different stages of boiling, they being styled as spider (*makarsha*) bubbles, mustard flower (*sarsafuli*) bubbles, tiger (*baghai*) bubbles and treacle (*guria*) bubbles, which last indicate that the process is nearly complete. The liquid is finally of a lovely golden colour and is ladled out into earthen pots or jars varying from 5—20 seers in content and allowed to cool to form gur. Before being poured into these pots, however, a handful of gur, called the *bichh* is added to the contents of each pan and the whole well stirred. The crystals added promote crystallisation in the liquid. This *bichh* is prepared daily and great attention

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1 The size of the furnace and number of pans depend on the size of the garden of course. The writer has seen as many as 13 pans on one furnace.

is paid to its preparation. The process of preparing *bichh* is called *bichhmara* and is as follows. A small portion of the liquid as its boiling approaches completion is set apart in one of the pans and boiled down rather more rapidly than the liquid in the other pans. Great care is, however, paid to its boiling. When the liquid has reached a certain consistency the pan is removed from the fire. The attendant takes a stick and with it rubs a portion of the liquid vigorously up and down in the form of a streak on the inside of the pan. The streak of liquid gets more and more sticky and finally white crystals of sugar may be seen. The operator tells from the ease with which these crystals come whether the day's boiling will be good or not. If the liquid is too thin and crystals cannot readily be obtained the pan is returned to the fire and heating continued until the liquid is of the right consistency. It is then vigorously stirred after removal from the flame when it becomes a pasty mass. Any excess of this beyond the amount required for *bichh* is poured out into a flat basket whose surface has been wetted with water to prevent the sugary mass from sticking. A flat mass of sugar which sets to a hard cake is thus obtained. This flat cake is known as *Patali* and is commonly on sale as a sweetmeat in the date districts at about Rs. 2-8-0 to 3-0-0 per katcha maund.

The residue in the pans is soft and contains crystals which serve as nuclei for crystallisation when added as *bichh* to the main bulk of the boiled juice.

The fuel mostly employed for the boiling process is Sundri wood (*Heritiera littoralis*), which forms the principal part of the wild tree vegetation of the Sunderbans. The under leaves stripped from the date trees are also used as fuel as well as the wood of old date trees which have been cut down. Stalks of rahar (*Cajanus indicus*), which is often grown as an undercrop in date gardens are also commonly in use as a fuel. In a few places near railway lines coal has been used.

The outturn of gur is from $\frac{1}{7}$ to $\frac{1}{9}$ the weight of the juice.

For a description of the native methods of refining the gur and of the methods of making the various kinds of native date sugars see page 359.

Yield of Gur per Tree.

On page 325 it is shown that 170lbs. of juice per tree per season may be taken as a fair average yield. So that the average annual yield of gur per tree is 170/8 or 21·25lbs.

Enquiries among intelligent cultivators seem to shew this figure to be reliable. Three instances of these enquiries are given. From 120 trees one man produced 26 maunds of gur (pacca). This is equivalent to just over 17lbs. of gur per tree. To this must be added the amount consumed by him. A second man working with 80 trees reckoned he had produced from them 20 maunds (pacca) of gur. This is equal to 20lbs. gur per tree. A third man produced Rs. 135 worth of gur from 180 trees. Included in this was gur, etc., to the value of Rs. 35 consumed by his family. Rs. 135 is the equivalent of about 4,320lbs. of gur. Therefore the yield of gur per tree works out at 24lbs.

Yield of Gur per Acre.

Three hundred and fifty trees could conveniently be grown per acre, so that the yield per acre would be $350 \times 21\frac{1}{4}$lbs. equal to 3·3 tons. Actually only 240 trees are usually grown per acre, and this therefore equals 2·3 tons of gur which is still a much higher yield than is obtained from cane in Jessore.

It will now be of interest to quote the writings of various other authors on the yield of juice and gur from date trees.

Robinson[1] in some calculations of yields from date trees takes the first day's yield per tree as 10 seers, that of 2nd day's as 4 seers, and that of 3rd day's as 2 seers. This averages out at $5\frac{1}{3}$ seers of juice per collecting day. Robinson moreover states[2] that his figures are under rather than overestimated. From the preceding figures

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[1] Bengal Sugar Planter, page 51.

[2] Loc. cit.

he calculates[1] that the annual produce of a full-grown date plantation was $78\frac{3}{4}$ bazar maunds[2] of gur per Bengal beegah,[3] or nearly $19\frac{3}{4}$ seers or $39\frac{1}{2}$℔s. from each tree.

To arrive at this result he assumes that there are 160 trees per beegah, and that 69 of these trees are cut daily.

Sixty-nine trees yield bazar maunds 9, seers 8, daily of juice using his figures.

He takes the average productive season at 107 days. Thus the number of productive days per tree in a season is equal to $\frac{69}{160} \times 107 =$ 46. In this period, however, are included days in which the yield is diminished by rain or by fogs. To allow for this he deducts $\frac{1}{5}$ of the total yield. We then get daily 160×9 maunds 8 seers of juice which is equal to bazar maunds 787-20-13, as the produce in juice per season per beegah deducting $\frac{1}{5}$ for bad weather as above. The average produce per tree therefore comes out at maunds 4-36-4 or 392℔s.

A correspondent of the Calcutta Agricultural Society in a letter published in the 5th volume of the Society's Transactions and dated Jessore, July 1846,[4] gives the average yield from a healthy date tree for the season at 30 seers gur and from an indifferent tree at 10 seers of gur. He thence assumes an average of 15 seers of gur which is equivalent to 3 maunds, 30 seers of juice.

Drury[5] puts the average yield per tree of juice at 180 pints per year which is equivalent to 22 gallons or about 2 maunds 30 seers.

Referring to more recent figures Mr. Kirtane[6] in experiments made by him in the Rampura Parganna of the Indore State in 1901-02, found the average yield per day to be $4\frac{1}{2}$℔s. of juice per tree and the maximum daily yield of one tree 14℔s. The juice must have been richer than that of Jessore since 6℔s. of juice yielded one of gur.

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[1] Bengal Sugar Planter, page 55.

[2] One bazar maund equals 80lbs.

[3] Roughly $\frac{1}{3}$ acre.

[4] Bengal Sugar Planter, page 55.

[5] The Useful Plants of India, by Col. Heber Drury, London, 1873.

[6] Files of the Reporter on Economic Products.

In a note on the Administration of Bengal 1901-02 (published 1903), page 2, it is stated that a tree yields on an average 5 seers of juice every day and about 15 seers of gur per season. This is approximately the same figure arrived at by Robinson.

N. N. Banerjee[1] also quotes 5 seers per day as the average yield of juice per tree. He assumes the number of sap yielding days as 50 and hence arrives at the average annual yield of 250 seers per tree.

N. G. Mukerji[2] quotes this same figure.

U. N. Kanjilal[3] in a very good account of the industry puts the average yield of juice per tree at 10 seers a day. This is of course quite an impossible amount.

Westland[4] also quotes 5 seers per night (exclusive of the quiescent nights) as a regular average from a good tree.

H. D. Chatterjee[5] as a result of experiments on wild date trees in Khandwa, C. P., puts the average yield of juice per night there (exclusive of quiescent nights) at 3 seers per tree.

It might here be mentioned that the maple tree which is tapped for sugar in North America in a somewhat similar way produces on an average 4lbs. of sugar in a season. Its juice contains only 3 per cent. of sugar.

Experiments on Losses of Sugar during Boiling.

The following table explains the lines of these experiments. Boiling of the juice commences according to the time of year any time from 7 A.M. up to 9 A.M. It is all collected in the earthen pots placed over the furnace described at p. 349. No clarification of any kind is attempted and there is very little scum, as is seen by the table. A date palm leaf is immersed in the boiling liquid to keep it from frothing over. The juice is colourless or faintly brownish when collected

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[1] Quarterly Journal, Bengal, Vol. I, page 164.

[2] Handbook of Indian Agriculture, 2nd Edition, page 329.

[3] Indian Forester, December 1892, page 454.

[4] Report on the District of Jessore, Calcutta, 1874, page 164.

[5] Is it an experiment or a national industry ? Haridas Chatterji, Central India Press, Mhow, 1901, page 13.

and during the boiling gradually changes to a golden yellow. The boiling takes 3 to 4 hours and is stopped when the liquid reaches a certain stage of stickiness which is judged by dropping it from the end of a stick. The liquid is then placed in ordinary earthenware *ghurras* and stored away for 10 to 14 days to crystallise when it is taken to the towns and sold to the refiners or khandsaris. The boiling operation is described in greater detail at page 349 of this memoir.

Date.	Juice.				Gur.			Losses.		Remarks.
	Total weight.	Sucrose.	Reducing sugar.	Total sugar.	Per cent. gur from juice by weight.	Sucrose.	Reducing sugar.	Sucrose per cent.	Total sugar per cent.	
	lbs.	lbs.	lbs.	lbs.		lbs.	lbs			
4-12-11	65·0	7·84	0·27	9·33	14·35	6·44	0·37	17·86	16·03	Garden I, two pans.
7-12-11	158·15	19·19	0·58	23·19	14·66	17·62	0·52	8·91	8·24	Garden I, four pans.
7-12-11	158·15	16·32	1·08	19·87	12·56	14·82	0·82	10·12	10·11	Garden II, four pans.
8-12-11	142·01	17·29	0·76	19·90	14·01	13·31	0·51	23·02	22·39	Garden I, four pans.
9-12-11	190·54	20·52	1·61	21·76	12·89	17·04	1·31	16·96	17·08	Do.
11-12-11	148·30	15·50	1·52	20·51	15·70	14·84	1·34	4·26	4·93	Garden II, four pans.
19-12-11	121·4	14·18	1·86	18·09	14·90	13·07	1·69	7·83	7·98	Chowgachha, two pans.
20-12-11	107·5	12·36	1·52	17·12	15·93	12·36	1·35	·00	1·22	Do.
22-12-11	208·9	23·14	1·43	28·84	13·8	20·75	1·59	0·33	9·07	Tarpur.
5-1-12	244·9	21·79	2·97	32·68	13·34	19·08	3·90	12·44	7·19	Jhenidah, four pans.
6-1-12	115·63	11·49	1·19	17·00	14·70	11·25	1·59	1·71	...	Kaliganj.
17-1-12	313·92	31·31	2·82	38·94	12·40	29·06	2·11	7·19	8·67	Garden I, four pans.
21-1-12	227·07	23·93	2·84	32·37	14·26	23·88	2·44	0·21	1·68	Maladharpur, four pans.
22-1-12 {	545·30	56·30	7·63	73·19	13·42	51·14	7·36	9·16	8·49 }	Maladharpur, eleven pans.
	Duplicate	56·57	7·63		...	50·18	7·56	11·30	10·06	
23-1-12	199·0	19·12	4·95	27·16	13·65	18·87	4·10	1·31	4·57	Maladharpur, four pans.
31-1-12	393·62	...	..	48·00	12·19	{ 29·39 29·18	6·70 } 6·70	8·24	8·75	Garden I, four pans.
4-2-12	212·37	...	...	29·50	13·89	19·06	3·62	9·45	7·05	Jessore all jiran.
12-2-12	246·4	23·09	1·90	22·09	9·21	16·20	1·62	29·84	28·7	Mostly jiran juice.
13-2-12	251·9	22·87	5·26	20·31	8·06	12·54	2·60	45·17	46·2	Mostly dokat and partly lekat and jiran.
21-2-12	111·32	12·95	1·52	13·25	11·9[illegible]	9·34	0·99	27·88	28·6	Mostly jiran.

The experiments carried out during February 1911 shewed that very great loss of sugar had taken place during the boiling, varying from 28 to 46% of the total sugar.

The work of season 1911-12 however shews the loss to be much smaller but very variable. Here the loss of sucrose varies from 0 to 23% and the loss of total sugar from 1·22 to 22·39.

For the 20 experiments the average loss of sucrose works out at 12·5% and of total sugar to 12·2%.

When it is remembered that the juice is normally alkaline the loss of sugar during boiling should not be very high. At times however the juice when ready to be boiled is acid owing to fermentation having set in. Thus in the experiments carried out in February 1911 when the losses of sugar were so high all the juices were strongly acid.

The earthen pans in which the boiling is performed are never cleaned out. New pans are bought at the beginning of the season and after each day's boiling the syrup is simply drained out and the pans put by till the next day.

The same pans are in use daily throughout the season. One may imagine the filthy state to which they attain. Burnt sugar collects in the pans and must contribute largely to the dark colour of the gur. The reason why the pans are not cleaned out is that the people think if water is put into them they will crack when again put over the fire.

In order to give an idea of the amount and composition of the scum formed during the boiling the following figures are quoted :—

Juice.			Scum.		
Total wt. lbs.	Total sucrose lbs.	Reducing sugar lbs.	Total wt. lbs.	Sucrose lbs.	Reducing sugar lbs.
115·2	10·51	2·02	0·75	0·02	0·06
164·7	15·01	2·57	1·06	0·09	0·04
110·8	11·01	1·47	0·94	0·007	0·108
103·7	....	....	1·44	0·09	0·08
147·6	14·92	2·17	1·75	0·12	0·11
97·9	9·26	1·39	0·94	0 09	0·025

The conclusion is that the amount of sugar lost in the scum is not large, being much less than 1%.

The figures in the two preceding tables give an idea of the amount of juice which is usually boiled by a cultivator in the district. In the experiments above recorded the number of trees tapped for a single boiling varied from 20 to 130. It has been suggested that the introduction of iron pans for boiling would be an improvement, but it is a question if they would be worth while for such small amounts of juice. Again the man who only boils the juice from 20 trees daily cannot afford to invest in, say Rs. 20 for an iron pan.

Here it will be worth while to insert a few figures shewing the losses of sugar in boiling cane juice.

Leather[1] found in experiments at Cawnpore and Poona that the total loss of sugar on boiling cane juice into gur by the country open pan method was 9·76—13·95%.

Clarke[2] as a result of 13 experiments in the United Provinces found an average loss of total sugar of 15·7% and of sucrose of 19·7%. Clarke[3] has since shewn that about 5% of this loss goes in the scum which is skimmed off during boiling.

The author of this paper found as a result of 25 experiments at Partabgarh, United Provinces, in 1909-10 an average loss of sucrose of 18·45% and of the total sugar 14·80%.

The three sets of experiments outlined above shew that the average loss of cane sugar during the native process of boiling the juice amounts to not more than 20% and of total sugar 15%. Five per cent. of this loss is accounted for in the scum removed.

The average loss of sugar in boiling date juice was shewn by the writer's experiments to be 12·5% of the total sugar and about the same quantity of sucrose.

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1 Agricultural Ledger, 1896, No. 19, page 15.

2 Sugarcane at the Partabgarh Experimental Station, 1908, Bull. No. 13 A. R. I., Pusa.

3 "The Efficiency of the Hadi Process of Sugar Manufacture," Agricultural Jour. of India, Vol. V, Part I, page 38.

The fact that the percentage loss of sucrose and total sugar is about the same would appear to indicate that the sugar is actually being burnt up in the case of date juice. In the case of the cane juice a good proportion of the sucrose which disappears has been inverted and not altogether destroyed.

It is probable that the total destruction of so much sugar is due to the use of earthenware pans.

Owing to the structure of the furnace much of the sugar is caramelised. The date gurs and mollasses are much darker than the corresponding products from the cane. This is almost certainly largely due to this caramelisation of the sugar. Further, boiling down the juice in earthenware pans requires a much longer time than the same process would in iron pans and hence there is more opportunity for caramelisation to go on. One can see the sudden change in colour which the date juice undergoes on being put into the pans. From a colourless juice it turns brownish at once.

Quantity of Sugar stored in the Date Palm.

A tree which had been tapped at varying intervals during the season was cut down. It was about 30 feet high and had been tapped for some 18 years. The tree was sawn into logs at roughly every 5 feet from the base. By this means 6 logs were obtained. Measurements of each log were taken and one of them weighed, but unfortunately a mistake was made in the weighment. However by assuming the weight per cubic foot as 45℔s. an average figure for woods, we can get a very near estimate of the weight of the whole tree. The saw-dust obtained while sawing the tree into logs was collected. The head of the tree, that is, the top log containing the tapped surface, was sawn longitudinally into two pieces in order to get a sample of the wood as saw-dust. We thus obtained 7 samples of the saw dust.

Each of the 7 samples of saw-dust was immediately analysed within ten minutes of being collected. The sucrose and reducing

sugar were determined in each sample. The table sets out the total sugar per cent. in the tree at various points. No. 1 sample was from the base of the tree and No. 7 was from the top portion—

No. of sample.	Total sugar. Per cent.
1	1·03
2	1·48
3	3·00
4	4·40
5	4·70
6	4·90
7	4·10

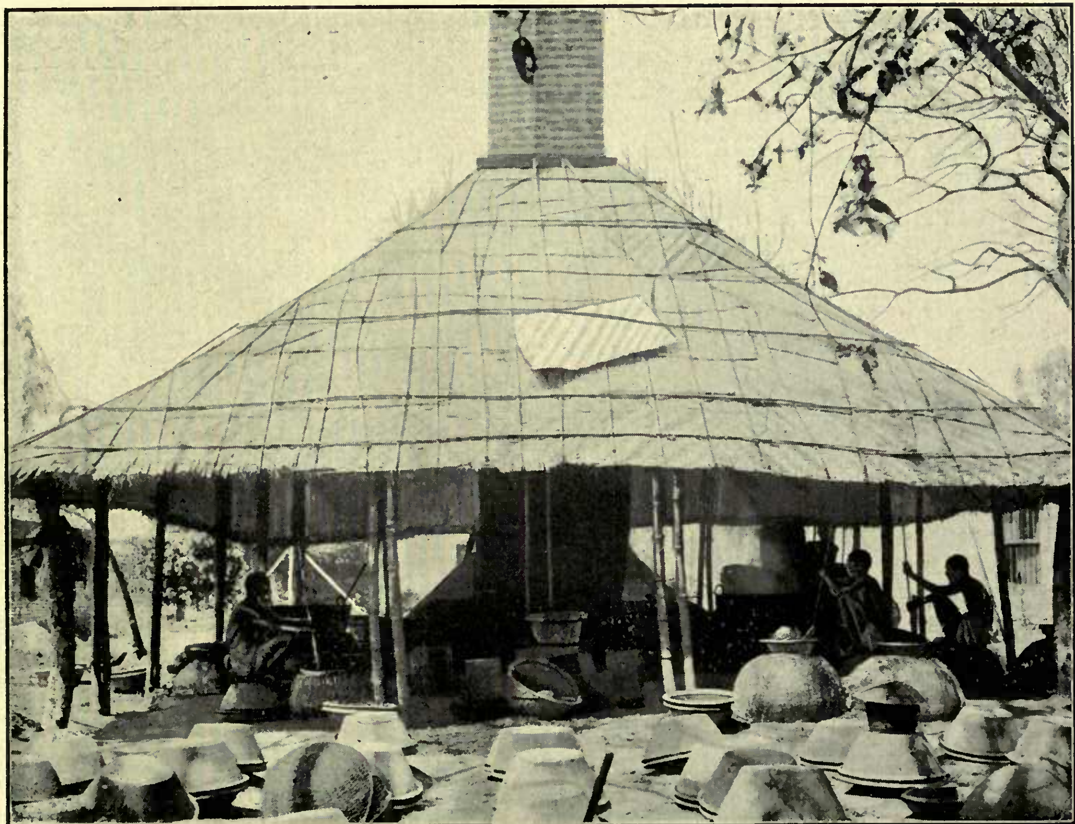
It is interesting to note that there was only the slightest indication of bleeding from the stump of the tree. At no portion of the tree was the cut surface notably damp, but the sawn surfaces became gradually damper as one proceeded upwards.

The total volume of the tree was 17·65 cub. feet. At 45lbs. per cubic foot the tree would, therefore, weigh 794·5lbs. The accompanying table sets out the weight of the various logs—with the weight of sugar in each.

Log.	Total weight.	Total sugar.
	lbs.	lbs.
Top log	65	2·67
Next lower log	108	5·18
Do.	135	6·21
Do.	153	5·80
Do.	157	2·75
Lowest log	175·5	2·20
	793·5	24·81

The tree therefore contains only about 25lbs. of sugar altogether. Further there is no special accumulation of sugar at the top of the tree. It has been shewn that an average tree yields about 22lbs. of gur per season. This tree had only been tapped a few times during the current season. Therefore it is reasonable to assume that the sugar is being formed from some other substance, probably starch, during the bleeding process.

PLATE VIII.



Native sugar refinery.—Boiling place. The molasses is here reboiled into a second crop of gur. The iron pans can just be made out. In the foreground may be seen the pots containing the molasses gur, which are buried to the neck in the ground. Their mouths are covered with earthen pans, but one in the right foreground is uncovered.

With regard to this point Brandis[1] says that preparatory to the production of flowers and seed the parenchyma in the trunk of Phœnyx is full of starch which at the time of flowering is transformed into sugar.

The Native Refining Process.

The khandsaris (refiners) having purchased the gur from the middlemen, break the pots and scrape out the contents. It is then broken up and placed in big baskets, each of $2\frac{1}{4}$ maunds capacity. The baskets, supported by bamboo triangles, are put over earthenware pans and left in the open and the molasses allowed to drain for 3—4 days. The baskets are next put inside a shed over similar pans and a layer 4—5 inches deep of moist *pata shyali* (Vallisneria spiralis), a water weed, is put on the surface of the sugar. Moisture drains down through the sugar, washing out the molasses. The weed has the property of taking up moisture from the atmosphere and thus keeps more or less damp for some time. It is also credited by the natives with the property of bleaching the sugar. After a week the *shyali* is removed and a layer of white sugar 3—4 inches deep has been formed. This is then cut off by knives, broken up and spread in the sun on grass mats to dry, being pressed with the feet of the coolies from time to time (see Plate I). When dry it is beaten up with wooden mallets to make it look whiter. The water weed is then replaced by fresh weed and after a week 3—4 inches more of sugar is removed. The contents of several baskets are then mixed to make up one basket and the process repeated until all is finished. At Kotechandpur sugar prepared in this way is called Akrah. At other places it is called Dulloah or Dollo. The baskets used in the process are boiled in water from time to time to prevent fermentation of the sugar which would otherwise take place.

The molasses collected by simple drainage is called *Agamata*. That collected under the water weed treatment is called *Farasu-*

[1] Indian Trees, p. 643.

mata. These two kinds are mixed in equal proportions and boiled down to get second gur by the refiner himself. Each refiner has his own boiling pans in his factory yard. A photo of these boiling pans is shewn in Plate IX. They are also seen in the background in Plate VIII. They consist of generally 4 iron pans each of capacity $1\frac{3}{4}$ bazar maunds of juice. They are arranged regularly around a central chimney stack and each has a furnace under it. Coal is usually burnt. The whole is covered by a roof. When boiling is complete the thick liquid is transferred to a large earthenware pot.

A handful of raw sugar crystals is now stirred in to encourage crystallisation, the stirring being continued for some time. The liquid is now transferred to big earthenware pots of the shape shewn almost completely buried in the soil as illustrated in Plate VIII. An earthen pan is placed over the mouth and the pots left for about 3 weeks to crystallise. In Plate VIII these partly buried pots are seen in the foreground with their mouths covered over. The open mouth of one is seen to the right of the picture. Each pot holds about 3—4 maunds. Burying the pots in earth prevents the liquid being disturbed, any disturbance being detrimental to the formation of good crystals. Also cooling takes place more slowly and slow cooling encourages large crystal formation.

This second gur finally goes through the same processes of draining off molasses in the open and then by the use of water weed, as the gur does. The sugar however is not supposed to be of such good quality. It is called Gnour at Kotechandpur.

The final molasses is called *Chitu.* The following table shews one experiment on the determination of the loss of sugar taking place during the boiling of the first molasses. With the huge fire kept up much of the sugar is burnt and it is surprising the loss is not greater than is shewn in the table.

PLATE IX.

Dobarrah sugar manufacture.—The boiling pans. The large iron pans as well as the small brass ones are shewn. In the foreground is seen a pot of the boiled product being treated with water weed to refine it to white sugar.

Date.	Molasses.						Gur.						Losses.				
	Total weight.	Cane sugar.	Reducing sugar.	Sucrose.	Reducing sugar.	Total sugar.	Total weight.	Sucrose.	Reducing sugar.	Sucrose.	Reducing sugar.	Total sugar.	Sucrose.	Reducing sugar.	Sucrose.	Reducing sugar.	Total sugar.
	lbs.	per cent.	per cent.	lbs.	lbs.	lbs.	lbs.	per cent.	per cent.	lbs.	lbs.	lbs.	lbs.	lbs.	per cent.	per cent.	per cent.
3-3-11	123	64·68	15·7	79·56	19·31	98·87	105·5	70·63	8·83	74·51	9·32	83·83	5·05	9·99	6·35	51·74	15·21
								70·63	8·83	74·51	9·32	83·83					

A duplicate analysis was made of the gur and it is quoted. Analyses are also given of the 3 kinds of molasses, *viz.*, *Agamata*, *Farasumata* and *Chitu*.

No.	Date.	Description of sample.	Cane sugar.	Reducing sugar.
			per cent.	per cent.
1	3rd March 1912..	Agamata	63·44	16·05
2	....	Farasumata	66·54	14·72
3	4th March 1912..	Farasumata	49·32	17·66
4	Do. ..	Chitu (final molasses) ..	32·49	20·18
5	Do. ..	Chitu	31·11	17·66
		Final cane Molasses (Country process).[1]	35·92	20·30

An analysis of final molasses from cane sugar is added to the table for comparison. This molasses was obtained by centrifugalising the rab, boiling down the molasses again, and after crystallisation centrifugalising again.

Nos. 1 and 2 were mixed in equal proportions to form the molasses used for the boiling experiment. Nos. 4 and 5 were samples drawn from different lots of sugar.

The amount of raw sugar and molasses obtained by this native refining process is fairly constant from year to year and in all the factories. I am much indebted to Mr. H. C. Macleod for kindly placing the books of various factories at my disposal.

[1] Clarke & Banerji, Efficiency of the Hadi Process, Agri. Jour. of India, Vol. V, Part I, page 35.

Including first and second sugar and molasses and taking the average of three factories for 10 years past we get the following figures :—

Weight of gur.	Weight of 1st and second sugar.	Weight of molasses.	Wastage.
100	41	50·5	8·5

Of the 41 per cent. of raw sugar obtained 29·5 are recovered in the first sugar and the remainder, 11·5, in the second sugar.

To shew how constant is the amount of sugar obtained from the gur the following figures are given shewing the extreme variation in the three factories over the past 10 years. From 100 parts of gur the amount of sugar obtained varied from 37·5 to 43·7 and of molasses from 48 to 55·3.

Each of the three factories above-mentioned refines from 9,000 to 12,000 bazar maunds of gur annually.

The price paid for gur by the refiners varies considerably from year to year. If raw sugar sells at a good price one year, then gur next year goes up in price. With a decrease in the selling price of raw sugar there follows next year a decrease in the price of gur.

Prices of Gur and Molasses.—The following table sets out for 12 years, the price at which gur was bought and sugar and molasses sold by three refineries in Jessore District :—

Season.	Price of gur per md. katcha.[1]			Selling price of sugar per md. katcha.			Molasses sold per maund katcha.		
	Rs.	As.	P.	Rs.	As.	P.	Rs.	As.	P.
1898–99	2	0	9	5	2	6	1	7	1½
1899–00	2	4	6	5	9	7½	1	9	2
1900–01	2	9	0	4	8	3	1	11	0
1901–02	1	14	9	4	3	2	1	5	9
1902–03	1	12	6	4	10	6	1	1	6
1903–04	1	13	6	4	4	0	1	3	10½
1904–05	2	3	7½	5	6	7½	1	9	3
1905–06	2	9	11	4	13	11	2	1	4½
1906–07	2	4	0	4	9	9	1	3	10
1907–08	2	0	0	5	4	0	1	7	0
1908–09	2	3	6	4	11	0	1	4	6
1909–10	2	5	4½	5	3	0	1	8	0

[1] One katcha maund = 40 seers of 60 tolas each; one pucca maund equals 40 seers of 80 tolas each and one pucca or bazar maund equals 82·2 lbs.

Sugar in 1899-1900 sold at the high price of Rs. 5-9-7½ per katcha maund. In 1900-01 the price of gur was very high indeed as a consequence, *viz.*, Rs. 2-9. The same effect was noticed in 1904-05 to 1905-06.

In 1901-02 sugar sold badly at Rs. 4-3-2 and the price of gur in 1902-03 fell in consequence to Re. 1-12-6.

A study of the above table shews what the ratio of the purchase price of gur to the selling price of the sugar must be in order to give a profit.

The cultivators do not sell gur direct to the refiners; a class of middlemen (Vern. *paikars*) exist, who go round and buy gur from the cultivators and then take it in carts to the refiners.

It appears that any rise of price in gur generally goes into the pocket of the middlemen, as the cultivators always get about Re. 1-14-0 from the paikars. This year (1911-12) the cultivators were getting from the middlemen Re. 1-14-0 to Rs. 2-0-0 per katcha maund for their gur, whereas the middlemen were getting Rs. 2-7-0 from the khandsaris.

The middlemen who have gur to sell bring it to the refiners stored in ghurras packed in carts. The purchaser tests its quality by pushing an iron auger into the gur. He can tell the amount of sugar crystals present by the amount of grittiness he feels and he pays for it accordingly. Last year (February 1911), Rs. 2-4-0 per katcha maund was being paid for the best quality. About 90 per cent. of all the gur is of this quality. For the next best quality Re. 1-14-0 was being paid and it represents about 3—4 per cent. of the gur. Of the worst quality there is only 2—5 per cent. and it fetches Re. 1-4-0 to Re. 1-6-0.

The accompanying table gives the analyses of a number of gurs.

Description of gur, native test.	Sucrose.	Reducing sugar.
	%	%
Best quality	72·56	6·92
Do.	79·69	5·01
Do.	77·21	5·51
Do.	75·04	3·30
Intermediate quality	61·40	12·59
Do.	70·35	9·54
Do.	54·57	8·83
Worst quality	60·39	15·32
Do.	61·95	14·80
Do.	53·33	16·85
Do.	58·46	16·59
Unclassed	71·40	12·10
Do.	61·76	12·82
Do.	70·47	7·46
Do.	73·39	11·04
Do.	66·40	10·09
Do.	74·13	7·04
Do.	79·26	10·09
Do.	73·51	9·30
Do.	74·07	9·30
Do.	69·05	3·93
Do.	75·98	2·23
Do.	74·57	4·13
Do.	66·88	2·58
Do.	69·40	5·30
Do.	73·07	6·60
Do.	72·24	9·34
Do.	72·17	7·86
Do.	71·94	5·53
Do.	42·23	26·88
Do.	66·16	9·37
Do.	58·38	11·94
Do.	74·63	5·41
Do.	73·77	7·59
Do.	69·87	10·06
Do.	69·47	15·08
Do.	61·23	13·96
Do.	64·61	12·28

The samples marked unclassed were the gurs examined in the boiling experiments. The other analyses shew that the native method of valuing is very reliable.

Marketing the products.—The following may be of interest in giving information as to where the sugar and molasses are sold. The prices obtained have already been shewn in the tables.

Raw sugar. Formerly this used to find markets in the Naraingani, Mymensingh, Tipperah and Barisal districts. Cossipore used to buy largely, but chiefly the lower qualities for refining. Within

the last three or four years the demand from all these quarters has almost ceased. Cossipore stopped taking it five years ago, since Java sugar has been low in price and they seldom take any now.

The present market is Calcutta where it is brought to meet up-country demands and largely used for sweetmeat making, and it is also refined by a country process at Sukchar near Calcutta. At Sukchar, Dobarrah and Akbarrah sugars are made in fairly large quantities.

Molasses. Until the last 3—4 years there used to be a good market for this around Dacca, Mymensingh and Barisal Districts, where it was used for mixing with tobacco for the native hookah. Some went to Sylhet where it was largely consumed as a food. Some always went to Calcutta for the rum factories. Since the advent of Java molasses the Sylhet market is cut off and the other districts mentioned only take it when the Java crop is short. The rest goes to Calcutta for making rum and country liquor and for mixing with tobacco.

Present Condition of the Native Refining Industry.

Most of the larger towns in the date-sugar-producing districts have their sugar karkhanas (factories), which give to the town a characteristic appearance. In the first place, one is struck by the good quality of the streets within the towns. This is due to the fact that the earthen pots in which the refiners buy the gur, after being smashed to obtain the gur, are thrown in heaps in the street. Dogs, jackals, sheep, goats and cattle may be seen in scores licking the sugar from the pieces. The pieces gradually get broken up and are then spread evenly over the road, and finally get broken down to a powder which makes a splendid road surface.

Next one cannot help remarking the number of old brick walls and chimney stacks. Each karkhana is surrounded by walls, on which are built godowns for the sugar. Kotechandpur at present reflects the declining state of the industry. One can see all round

dilapidated walls and chimneys, the remains of factories no longer working. Year by year more are passing into disuse, and whereas 20 years ago there were perhaps 80 karkhanas working in Kotechandpur alone, there are now only about 30. The year 1911-12 has shewn a tremendous falling-off in the amount of gur worked by the Kotechandpur karkhanas, the amount being only about $\frac{1}{3}$ of that worked last year. This was mainly due to the fact that the karkhanas would not pay the high price, Rs. 2-7-0 per katcha maund, which the middlemen were asking for the gur. When it was seen how fast the price of sugar was rising, the owners of karkhanas began to feel sorry they had not bought more gur at Rs. 2-7-0. Akrah sugar, the product of the karkhanas, was, in February 1912, selling at a higher price than has ever been known before in the history of the date-sugar industry. The gur was consequently being exported to other districts and even to Calcutta, where the price of better classes of sugar being so prohibitive, the date-sugar was in large demand for direct consumption by the people.

The following account sheets shew the scale on which a karkhana works, and also the cost of working it. The figures have been obtained through the courtesy of H. C. MacLeod, Esq., of Kotechandpur and are quite reliable, the writer having been kindly given access to the account books of the factory.

The three years have been selected at random and are quite typical. 1906-07 and 1908-09 were obviously bad years for the karkhanas and 1907-08 a very good year. 1906-07 was a bad year because the prices obtained for the sugar and molasses produced were very low, *viz.*, Rs. 4-8-1½ and Re. 1-3-10½ respectively. 1907-08 was a good year due mainly to the low prices at which gur was bought (*viz.*, Re. 1-15-10½), and to the good prices obtained for sugar and molasses, *viz.*, Rs. 5-4-0 and Re. 1-7-9 respectively. 1908-09 was again a bad year owing to sugar only fetching Rs. 4-12-10½ and molasses Re. 1-4-7½ per katcha maund. In the accounts no allowance has been made for interest on capital. This is generally put at 12½ per cent. in the district.

During the three years 1906-07, 1907-08 and 1908-09 the cost of working one katcha maund of gur in 3 factories has varied from annas four, pies ten to annas five, pies four and a half. This figure is exclusive of interest on capital.

1906-07.

Expenditure.	Rs.	A.	P.	Income.	Rs.	A.	P.
House rent	400	0	0	By sale of 3,423 mds. 37 srs. 3 chhataks sugar.	15,439	11	6
Breaking pots	82	12	6	By sale of 4,746 mds. 12 srs. molasses.	5,875	7	0
Servants' food	229	12	4½	Balance (loss)	2,179	2	10½
Municipal tax	32	14	0				
Wages to coolies	828	5	3				
Gunny bags	143	5	6				
Weeds (*Vallisnerice*) See page 359	129	8	0				
Coal	287	12	9				
Empty pots in which molasses are sold.	188	12	0				
Commission to buyers' agents	50	5	9				
Miscellaneous	405	11	6				
Baskets and mats to replace old ones.	191	2	6				
Bad debts	1	7	6				
Purchase of 9,005 mds. 15 seers of gur.	20,542	7	9				
Total ...	23,494	5	4½	Total ...	23,494	5	4½
Average cost of working 1 md. gur.	0	5	3				

1907-08.

Expenditure.	Rs.	A.	P.	Income.	Rs.	A.	P.
House rent	465	0	0	By sale of 4,180 mds. 12 srs. 12 chhataks sugar.	21,926	12	3
Breaking pots	89	15	9	By sale of 4,645 mds. 1 sr. 4 chhataks molasses.	6,892	2	0
Servants' food	163	11	9				
Municipal tax	31	6	6				
Wages to coolies	833	8	0				
Gunny bags	132	15	9				
Weeds	138	0	6				
Coal	299	11	6				
Empty pots in which molasses are sold.	232	11	6				
Commission to buyers' agents ...	51	4	3				
Miscellaneous	589	9	3				
Baskets and mats to replace old ones.	9	15	6				
Purchase of 9,568 mds. 11 seers of gur.	19,096	5	6				
Balance profit	6,684	10	6				
Total ...	28,818	14	3	Total ...	28,818	14	3
Average cost of working 1 md. gur.	0	5	1				

1908-09.

Expenditure.	Rs. A. P.	Income.	Rs. A. P.
House rent	475 0 0	By sale of 5,922 mds. 21 srs. sugar.	27,559 0 9
Breaking pots	128 6 6	By sale of 6,758 mds. 28 srs. 8 chhataks molasses.	8,692 5 9
Servants' food	226 0 3		
Municipal tax	51 9 6		
Wages to coolies	1,266 12 9		
Gunny bags	93 2 3		
Weeds	183 8 0		
Coal	485 4 6		
Pots in which molasses is sold	310 6 6		
Commission to buyers' agents	11 14 9		
Miscellaneous	1,006 11 0		
New baskets for draining gur...	33 5 9		
Bad debts	4 8 0		
Purchase of 13,822 mds. 34 seers of gur (katcha).	31,066 11 0		
Balance (profit)	908 1 9		
Total ...	36,251 6 6	Total ...	36,251 6 6
Average cost of working one maund gur.	0 4 11¼		

History of the Native Refining Process.

The pioneers of the process were certain members of the *Mayra* or confectioner's caste who started operations about 1820. The table[1] will give an idea of the rapidity of growth in numbers of these native refineries. We have only been able to find figures for the Jhenidah and Magurah sub-divisions of Jessore.

Year.	Number of factories.	Outturn of sugar maunds katcha.	Outturn of treacle.
1861–62	....	4,465	1,042
1862–63	10	27,215	10,595
1863–64	15	10,633	4,242
1864–65	19	32,675	18,556
1865–66	24	40,009	31,577
1866–67	36	49,713	36,183
1867–68	47	46,671	59,446
1868–69	55	56,898	86,518
1869–70	65	71,251	87,873
1870–71	75	79,032	90,632
1871–72	85	90,222	90,021
1872–73	113	136,992	197,389

[1] Taken from Report on the Agric. Statistics of Jessore, Jhenidah and Magurah sub-divisions, 1872-73. Babu Ramshunkar Sen.

It can be seen from this table how rapid was the growth of this native refining industry. In course of time it practically monopolised the sugar trade and throve till about 1890 when it began to suffer from the competition of imported sugar. This decline has continued, but in 1900-01 there were in Jessore district 117 factories with an outturn valued at Rs. 15,15,000. These small factories are scattered over the district along the banks of the various rivers, but the great centre of manufacture and trade is the town of Kotechandpur on the Kabadak river. In spite of this decline Jessore is still the chief date-sugar-producing district in Bengal, the outturn per annum being estimated at 1,221,000 cwts. out of a total of 1,559,679 cwts. for the whole province.[1]

The Native Date-Sugars.

The native date-sugars on the market with their approximate prices[2] are :—

	Price per md. Rs.	As.		Rs.	As.
Dobarrah	11	0	to	11	8
Akbarrah	10	0	,,	10	8
Jodurhatty Dollo	8	8	,,	9	8
Goburdanga Dollo	8	0	,,	9	0
Gnour	6	8	,,	7	0
Akrah	6	0	,,	6	4

The way in which Akrah, Gnour and Dollo sugars are prepared has been described at page 359.

The prices are difficult to understand. Jodurhatty Dollo is quoted at a 50 per cent. higher price than Akrah, whereas both are prepared by an exactly similar process. For information as to the manufacture of Jodurhatty Dollo we are indebted to the Office of the Director of Agriculture, Bengal. We are informed, however, that smaller quantities of gur are refined at Jodurhatty and Goburdanga than at Kotechandpur, and a better quality of sugar is thus obtained at the former places. The appearance of the sugars presents some

[1] N. N. Banerjee. The date sugar palm. Quarterly Journal, Bengal Agricultural Department, January 1908, pp. 161-62.

[2] *Capital*, 27th April 1911.

differences. Goburdanga Dollo and Jodurhatty Dollo are distinctly whiter than Akrah.

However, Gnour has been frequently quoted in *Capital* at a higher price than Akrah. In appearance it is a long way inferior, being a dirty brownish sugar, whereas all the others are greyish white. By its origin also we know that it is an inferior sugar.

The Kotechandpur refiners get a higher price for their Akrah. In April 1911, Kotechandpur Akrah was selling in Calcutta at Rs. 6-10-0 to Rs. 6-12-0 per bazar maund and Kotechandpur Gnour at Rs. 6-2-0 to Rs. 6-6-0. Personal enquiries by the author in the Calcutta sugar market would seem to show that the higher quotation of Gnour than Akrah was a mistake, as the dealers say Akrah always fetches a higher price.

Dobarrah and Akbarrah Sugars.

The process of making these sugars has not varied much from what it was 50—60 years ago when Robinson described it.[1] Dobarrah is the highest state of refinement except candy to which native sugar is brought. It is made only from Dollo, Akrah or Gnour. As a rule, these are sold direct to big markets such as Calcutta, but when they are only fetching a low price, some of the Khandsaries make them into Dobarrah and Akbarrah sugars, which are very highly refined products.

In the process, as we have seen it, two under-ground furnaces are prepared, the fuel in use being coke. On each of these a big iron pan is placed. Each was 3′ 5″ in diameter and 20″ deep. Each pan is now about $\frac{1}{3}$ filled with lime water which had been made by adding 1 seer of lime to about 6 maunds of water and after continued stirring allowed to stand overnight. All earthen pans in which Dobarrah and Akbarrah sugars had been prepared and which were now empty are well rinsed in the iron pans to get out any sugar. About $4\frac{1}{2}$ maunds of (370lbs.) Akrah sugar are now placed in each

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[1] Bengal Sugar Planter, Robinson, p. 83.

pan and well mixed up with the lime water. More water is now added equal in bulk to that of the lime water originally present. The contents of the pans are now heated with continued stirring and any pieces of foreign matter such as pieces of *ghurras* taken out by means of a perforated ladle. Two brass pans 20″ in diameter and $8\frac{1}{2}$″ deep are now carefully cleaned and one put by the side of each of the big melting pans. Two seers (4lbs.) of milk are placed in each and then they are filled with water. When the liquid comes to the boil this diluted milk is gradually sprinkled over the surface of the boiling liquid until it is all used up. Scum is removed after each sprinkling with milk by means of flat perforated iron ladles. Rather a liberal amount of scum is taken off but it is all carefully preserved in a spare pot. After 3 or 4 hours all the sugar has dissolved and all the scum has been removed. The fire is then damped and one bucketful of cold water added to each of the melting pans. A third large iron pan equal in size to each of the melting pans is now put ready with a cloth strainer over it. The hot liquid is strained through this into the third pan and it is now ready for a final clarification and concentration. The scum removed from the melting pans is now put back into one of them again and reboiled and reclarified with milk. There is so much scum that it fills one-third of one of the pans. Pieces of grass and dirt are taken out of the scum with a ladle, being carefully washed with diluted milk on the ladle and well pressed before being thrown into the fire. After 10 to 15 minutes the liquid is removed from the fire and strained through gunny cloth. The strained liquid is put on the melting pots at the next melting of Akrah. The scum, which is a black mass, is re-boiled with lime water and after further straining thrown away. The iron melting pans having been removed from the fires, the brass pots above mentioned are put on in their stead. Each is three-fourths filled with hot strained juice which is now brought to the boil. One spoonful of milk is added to the boiling liquid from time to time and any scum is skimmed off, but it only forms in small quantities. The liquid is of a lovely golden yellow colour and is boiled until it shews signs of stickiness on

being dropped from the end of a stick. In all, three to four spoonfuls of milk are added.

The concentrated clarified liquor is now poured into a shallow earthenware pan 21″ in diameter and $8\frac{1}{2}$″ deep and put by in a store-room. The brass pans are again filled and the process repeated until all the contents of the storage pan have been worked off.

A number of flat earthenware pans are thus obtained, each containing concentrated liquor. In about 6 hours crystallisation begins to take place. The liquor is never seeded with sugar crystals in order to make it crystallise as is done in some of these native processes.

By next day the contents of each pan have set to a solid mass with a yellow brown glassy surface. If the surface is sunken in the middle, the refiners say the boiling has been bad and the sugar will not be of the best quality.

Two days later the glassy surface is scraped to loosen it and then a layer of about 3″ thick of water weed (*Vallisneria spiralis*), locally called *pata shyala*, is put over the surface. This weed remains moist for a long time. A hole is now driven through the bottom of the pan by means of an iron punch and hammer and the hole made right up through the sugar.

The pan is next placed on a triangular frame work, over an earthenware pot. Molasses drains away from the sugar. It might be mentioned here that these pans are later repaired by simply sticking thick paper over the hole and are thus able to be used over and over again.

After 4 days the *shyala* weed is removed and the top half of the contents of the pan is a pure white rather large-grained sugar and is broken up and spread in the sun to dry on bamboo mats. This is Dobarrah sugar.

The nether portion of the sugar is still mixed with some molasses and is brown. The nether portions of two or more pans are mixed until sufficient is obtained to make up another pan, and then *shyala*

weed is again applied to the surface. After another 4 days a fresh crop of Dobarrah sugar is obtained from the surface. The nether portions, which are still brown, are mixed with the two lots of molasses obtained above and reboiled. The clarifying, boiling, and weeding are carried out in an exactly similar way as when first boiling the Akrah alone. The resulting sugar is Akbarrah. It is of rather smaller grain than Dobarrah and of slightly reddish tinge. The syrup from Akbarrah is sold as molasses and at times attempts are made to reboil this syrup into a third grade of sugar called *petiar chini*, but in the case we saw the attempt was not successful. We made an analysis of the liquor and found—

Sucrose	55·6
Reducing sugar	33·96

It was not surprising that no crystals could be obtained in this case. The nether portions of sugar of the Akbarrah draining pans are still brown and are mixed with the next lot of Akbarrah boilings.

The following analyses shew the composition of samples taken at Kotechandpur of Dobarrah and Akbarrah sugars and of the Akrah sugar from which these were made.

	Sucrose.	Reducing sugar.
Dobarrah	98·32	0·78
Akbarrah	97·18	1·47
Akrah	94·43	2·33

The author has met with Dobarrah sugar, containing 99·4 per cent. sucrose and only a trace of invert sugar. The Akrah analysed above was richer in sucrose than this sugar usually is.

Consumption.—They are mainly consumed by the richer classes of natives such as the Marwaris, who give a high price because the sugars are prepared in accordance with their caste prejudices.

Samples of all the above native date-sugars, as quoted in *Capital,* were kindly obtained for us from the Calcutta market by the Office of the Director of Agriculture, Bengal.

Analyses have been made to see if the sugar contents justified the large differences in price between the sugars.

	Dobarrah.	Akbarrah.	Jodurhutty Dollo.	Goburdanga Dollo.	Gnour.	Akrah.
Sucrose ..	98·48	98·37	96·50	95·17	91·74	92·75
Reducing Sugar	0·81	1·14	1·62	1·91	2·86	2·19
Water ..	0·22	0·30	0·82	0·91	1·40	0·94
Total ash ..	0·05	0·09	0·23	0·41	1·11	1·22
Organic matter not sugar ..	0·44	0·10	0·83	1·60	2·89	2·90
	100·00	100·00	100·00	100·00	100·00	100·00
Insoluble matter	0·01	0·14	0·45	1·35	1·68	1·31
Soluble ash ..	0·00	0·00	0·10	0·20	0·10	0·02

To show that the native does not pay for his sugar on the sucrose content but that the prices depend on mere fancy the following analyses and prices are quoted. These prices are taken from *Capital* of the same date from which those of date-sugars on page 369 were taken.

Description of sugar.	Price per bazar maund.	Sucrose. %	Reducing sugar. %
Java T. M. O. white	7 3 0	99·60	0·25
,, brown	6 4 0	97·54	not determined
Cossipore first white	8 8 0	99·90	trace
Dobarrah	11 4 0	98·48	0·81
Akbarrah	10 4 0	98·37	1·14
Jodurhatty Dollo	9 0 0	96·50	1·62
Goburdanga Dollo	8 8 0	95·17	1·91
Gnour	6 12 0	91·74	2·86
Akrah	6 2 0	92·75	2·19

For convenience of reference the date-sugars are inserted on the table and the average quotation price is put beside them.

From the analyses it is seen that Akrah is distinctly a better sugar than Gnour. Since also we know by its process of manufacture that it is a better sugar, it is, as before stated, probable that a mistake has been made by *Capital* in the quotation of Akrah and Gnour.

The Dollo sugars are certainly much better than Akrah, but it seems hard to find a reason for the fact that Jodurhutty Dollo is quoted at a 50 per cent. higher price than Akrah.

Java T. M. O. white is a better sugar than Dobarrah though it fetches only 60 per cent. of the price the latter does. In this case one must put down the difference in price to the great prejudice in favour of native sugars.

The following are the only other analyses of date sugar which I have been able to find.

The first is described as an analysis of date sugar as sold in Calcutta and is by M. Deon.[1]

	%
Sucrose	87·97
Reducing sugar	1·71
Gum	4·88
Water and volatile matter	1·88
Ash	0·50
Mannite, fatty matter, matters not estimated and lost	3·06
	100·00

M. Deon states that the sugar was in full viscous fermentation and that it is known that this fermentation is accompanied by the formation of mannite and a gummy substance. This gum is soluble in water, insoluble in alcohol, precipitated by sub-acetate of lead, dextrorotatory, without action on Fehling solution and converted into glucose on boiling with dilute acids.

Thorpe's Dictionary of applied chemistry[2] quotes an analysis made in England of palmyra jaggery.

	%
Sugar	78·00
Glucose	8·93
Ash Soluble	1·71
,, unsoluble	0·86
Moisture	6·74
Undetermined organic matters	3·76
	100·00

1 Bull. Soc. Chim. de France.

2 Vol. III, p. 624.

Deterioration of Date Sugars on Storage.

Some date sugars which were analysed in June 1911, were stored away in glass stoppered bottles. On opening the bottles in April 1912 all the samples had a more or less offensive smell and all the sugars were again analysed. It was found that a good deal of change had gone on in their composition. The results are set out in the accompanying tables.

	June 1911.			April 1912.		
	Sucrose.	Reducing sugar.	Total sugar.	Sucrose.	Reducing sugar.	Total sugar.
Dobarrah	98·48	0·81	99·29	97·07	2·64	99·71
Akbarrah	98·37	1·14	99·51	96·62	2·79	99·41
Akrah	92·75	2·19	94·94	88·32	4·56	92·88
Gnour	91·74	2·86	94·60	87·25	5·95	93·20
Jodurhatty Dollo ..	96·50	1·62	98·12	91·52	5·18	96·70
Goburdanga Dollo ..	95·17	1·91	97·08	92·64	3·88	96·52

A fresh set of samples of date sugar made in 1911-12 season were analysed and put up in glass stoppered bottles on May 5th, 1912. They were again analysed on 18th June 1912. The results are here set out.

	5th May 1912.			18th June 1912.		
	Sucrose.	Reducing sugar.	Total sugar.	Sucrose.	Reducing sugar.	Total sugar.
Dobarrah	98·81	0·88	99·69	98·58	1·11	99·69
Akrah	94·43	2·33	96·76	93·95	2·94	96·89
Chulta	94·56	3·99	98·55	93·40	2·55	95·95
Gnour	95·48	2·61	98·09	92·19	5·04	97·23

The table shews that even in such a short period as 6 weeks these native prepared sugars have deteriorated to a large extent. Greig Smith[1] and Owen[2] have observed this deterioration of raw sugars on storage. We have not examined the nature of the change, but it is probably bacterial as was shewn by Greig Smith in the case of Australian raw sugar.

[1] Greig Smith. Proc. Royal Society, N. S. W.

[2] W. L. Owen. Bacterial Decomposition of Sugars, Louisiana Planter, 1911, 46, 153-5.

PART IX.

COMMERCIAL.

PAST AND PRESENT PRICES OF GUR, AKRAH AND MOLASSES.

IN the following table have been collected together the prices of the above products for as many years as I have been able to find them.[1]

YEAR.	PRICE PER KATCHA MAUND.		
	Gur.	Akrah.	Molasses.
	Rs. A. P.	Rs. A. P.	Rs. A. P.
1832	1 2 0	3 10 3	
1833	1 2 6	3 10 0	
1834	1 5 4	4 2 4	
1835	1 11 8	4 7 6	
1836	1 7 0	4 4 9	
1837	1 10 6	4 6 9	
1838	1 10 0	4 6 3	Average 0 12 0
1839	1 12 0	5 10 6	
1839—40	1 14 11	6 5 5	Varied from 0 8 0 to 2 0 0
1840—41	3 1 9	8 6 10	
1842	1 12 0	4 14 3	
1843	1 15 0	6 12 5	
1844	2 0 0	6 12 5	
1845	1 13 0	6 10 9	
1846	1 14 0	7 13 0	
1847	1 14 0	5 14 6	
1852	0 12 0		
1861—62	......	4 0 0	1 0 0
1862—63	......	7 15 0	0 6 6
1863—64	......	9 3 0	1 1 0
1864—65	......	3 12 0	1 15 0
1865—66	......	4 1 6	1 1 6
1866—67	......	4 15 0	1 6 0
1867—68	......	12 10 0	1 2 6
1868—69	......	5 5 6	1 2 6
1869—70	......	6 6 0	1 3 6
1870—71	......	6 1 3	1 2 0
1871—72	......	6 5 0	1 2 0
1872—73	......	5 15 0	2 0 6
1873	1 13 0	7 0 0 to 10 8 0	

[1] Bengal Sugar Planter. S. H. Robinson, 1849 Report on the Agric. Statistics of Jessore, 1872-3, B. Ramshunkar Sen.

Year.	Price per Katcha Maund.		
	Gur.	Akrah.	Molasses.
	Rs. A. P.	Rs. A. P.	Rs. A. P.
1898—99	2 0 9	5 2 6	1 7 1½
1899—1900	2 4 6	5 9 7½	1 9 2
1900—01	2 9 0	4 8 2	1 11 0
1901—02	1 14 9	4 3 2	1 5 9
1902—03	1 12 6	4 10 6	1 1 6
1903—04	1 13 6	4 4 0	1 3 10½
1904—05	2 3 7½	5 6 7½	1 9 3
1905—06	2 9 11	4 13 11	2 1 4½
1906—07	2 4 0	4 9 9	1 3 10
1907—08	2 0 0	5 4 0	1 7 0
1908—09	2 3 6	4 11 0	1 4 6
1909—10	2 5 4½	5 3 0	1 8 0

Certainly since 1898 there does not seem to be any tendency towards a marked increase of price of either date sugar, molasses or native refined sugar.

In the case of cane gur on the other hand during this same period there has been an increase in price of something like 25 per cent.[1] Date gur in ordinary years does not fetch more than Rs. 2-4 per katcha maund. This is equivalent to Rs. 3 per pucca maund and is considerably less than the price of cane gur.

Profits of the Industry.

It is a matter of extreme difficulty to set forth satisfactory estimates showing the profits to be derived from the industry. The writer however has carefully studied a number of estimates which have been previously published. By the help of these and of personal enquiries among the cultivators he has arrived at the following figures. In the calculations he has taken 350 trees as the basis, the number which could be grown on one acre. For this they would have to be planted rather less than 12 feet apart. Two gachis (tappers) with an assistant (kheri) would be easily able to manage all the trees.

[1] Notes on Sugar in India, F. Noel Paton, p. 23, and also Rural Economy in the Bombay Deccan. G. Keatinge, p. 184.

Outlay.

	Rs.	A.	P.
2 Gachis for season	48	0	0
Kheri	15	0	0
Food for above	38	4	0
Fuel	30	0	0
Pots and pans	15	0	0
Daws	1	0	0
Rope	1	0	0
Rent	15	0	0
Ploughing and weeding	9	0	0
Jute	0	12	0
Clothes for kheri and gachis	2	0	0
Rent[1] to zemindar for keeping up a bain ..	2	0	0
TOTAL ..	177	0	0

Income.

350 trees at $22\frac{1}{2}$lbs. gur per tree produce 98·4 maunds (pucca), which, at 2-8-0 per maund, are worth Rs. 246-4-0.

Profit 69-4-0

It must be remembered that the first gur of the season, the *nolen-gur* fetches a much higher price than Rs. 2-8-0 per pucca maund which is the price taken above. So that the above income is much understated on this account.

The profit works out therefore at about $3\frac{1}{2}$ annas per tree per year and would make out the industry, even in its present state to be a quite remunerative one. Further, if the owner of the trees helped to work them himself he would save a good deal in wages.

The above calculations have not taken into consideration the fact that it takes 5 or 6 years from the time of planting before a garden comes into bearing. During that time the following expenses are incurred.

6 *Years' cost of getting Plantation ready for use.*

	Rs.	A.	P.
Cost of sowing seed	3	0	0
6 years' ploughing and weeding	50	0	0
6 years' rent	90	0	0
TOTAL ..	143	0	0

[1] The amount of this is based on the number of openings in the furnace such as spaces for pans, stoke holes, and smoke escape holes.

Since the garden will go on bearing for fully 25 years this amount is not very serious as in the long run it would add less than Rs. 6 per annum to the expenditure. Further, during these 6 years a certain amount of income can be obtained by growing crops on the land. The author has already stated reasons why he thinks the estimate of income is low and even allowing for the sum of Rs. 6 per annum he still thinks it is not too high.

At the same time it is obvious that a man who wishes to set out a date garden must have a fair amount of available capital.

Here it might be mentioned that trees are usually let for sugar manufacture at 8—16 to the rupee and the people themselves reckon on a profit of anything from 4 to 12 annas per tree.

The profit of Rs. 69-4-0 per acre does not represent the whole of the profit obtained from the garden for under the date trees a cold weather or *dhan* crop can be raised. If arhar is grown the stalks are extremely useful as fuel and this will tend to reduce the high figure allowed for fuel in the above estimate. The wood of the date trees is used as beams and posts in houses and as ladders in tanks and ghats. It is also used in constructing temporary bridges over streams and drains. The leaves cut off before tapping are used as fuel and last one month for this purpose. At Kaliganj bags are made from the leaves for exporting sugar.

PART X.

Suggestions for Improvements.

In the preceding pages we have shewn how important an industry the manufacture of date sugar is. The amount produced in Bengal alone is probably about 100,000 tons worth well over £500,000 sterling. This industry is a source of profit to a large number of people.

The methods of sugar manufacture and refining carried out in the district are very crude and in the author's opinion are capable and worthy of great improvement.

It has been shewn that even in the present state of the industry, by the regular planting of 350 trees per acre, one can expect as an average nearly 3 tons of gur per acre. This is a much higher yield than could be obtained in the district from sugarcane. Further, there is a good deal of risk in the growth of cane which may be damaged by floods, pests, etc., and also much labour and expense is involved in its growth. With date palm the yield of sugar is certain from year to year and very little expense has to be incurred for actual cultivation.

In these recommendations we are mainly considering the improvements from the point of view of a native industry.

At the same time there seems no reason, why with careful seed selection the amount of sugar in the juice should not be raised considerably and under these circumstances there *might* be openings for large central factories, especially as there would be no need of crushing apparatus, which is such an expensive part of a factory dealing with cane. As a set off against this, however, we must remember that the megasse or cane from which the juice has been extracted, serves as fuel in the cane sugar factory. In order to boil

the date juice fuel would have to be purchased. The writer here calls attention to the long season which is possible with palm sugars. Thus the date palm yields its juice in the cold weather, from November to March. The Palmyra Palm (*Borassus flabelliformis*) yields its juice in the hot weather from April to September. There are many places where these palms would grow very well side by side and thus a factory would be able to make its sugar boiling season last over practically the whole year.

In considering this subject of improvements it will be instructive to refer to the maple-sugar industry of North America. The early settlers in that country learned the art of making maple sugar from the Indians, who simply made axe-cuts in the trees and inserted a rough wooden spout, very similar to the bamboo spout now used in Jessore. The juice was collected in rough wooden troughs and boiled down in clay or bark vessels by dropping hot stones into the sap. The white settlers carried on the same process for one hundred years without material change, save for the substitution of iron or copper kettles for the clay or bark vessels. They also boiled the juice down over a fire of timber instead of dropping hot stones into it. The crude product of those early days was quite dark in colour and very unreliable in quality.

About the middle of last century a rapid improvement in the methods and machinery employed, took place.[1] Instead of the old destructive axe-cut, holes are carefully drilled into the trees with an auger or bit and closed metal spouts have been substituted for the old wooden spouts. Similarly, tin or galvanised iron pails fitted with covers have gradually taken the place of the rough wooden troughs which formerly caught the sap. At first the sap was generally carried to the fire in buckets by hand or with a shoulder yoke. But as the scale of operations increased, gathering tanks were introduced and are now used in all but the smallest groves. These are placed at convenient distances throughout the grove. From these pipes are often run through the grove to larger storage tanks

[1] See U. S. Dept. of Agri. Farmers' Bull., No. 252.

or the sugar house. In one large grove a narrow-gauge railway is used for collecting sap. The change in the actual process of making sugar is described as revolutionary. This is chiefly due to the supplanting of the iron kettles for boiling the sap by ingenious and cheap modern evaporators. These are long shallow tanks having partitions from side to side and open at alternate ends placed in them at intervals of 8 to 10 inches. The sap, whose flow is carefully regulated from a storage tank, enters the evaporator at one end and flows slowly across the pan from side to side, around the partitions until it reaches the far end. By this time it is reduced to the required density.

Improvements in methods of firing have been so great that consumption of fuel is much more economical than in the early days. It is understood that in some districts small vacuum pan plants are in use.

There is one great advantage which the date palm sap has over that of the maple. The former contains 10 to 14% of sugar, whereas the latter only contains about 3%. The average annual yield of sugar per tree is in the case of the date palm about $22\frac{1}{2}$ lbs., whereas the maple only yields about 3lbs. Further, one acre of land will accommodate many more date palms than maple trees.

At the same time maple sugar and syrup are luxuries and fetch much higher prices than date sugar. The maple sugar sells at 9 cents (equal to $4\frac{1}{2}$ annas) per pound, whereas date gur only brings in to the cultivator half an anna per pound.

We will consider proposed improvements in the date sugar industry under various heads.

I. Agriculture.

Cultivation.—Gardens, especially when young, should be well cultivated. They should be kept ploughed up in the hot weather as this will prevent to some extent loss of soil moisture.

Planting.—A regular system of planting should be followed so as to get the optimum number of trees per acre. The author

considers that trees may be safely put at distances of 11 feet apart each way, that is, 360 trees per acre.

Manuring.—At present the date gardens receive no manure, but it might be found that manuring would be beneficial.

II. Seed Selection.

It seems probable that much might be done by sowing seed taken from the trees which yield large quantities of rich juice. Since the thickest trees have been observed by us to be largest yielders, this selection should be a simple matter.

Near Jessore town at village Khartalar a number of gardens have been sown from seed taken from the excellent garden referred to on page 325. These gardens are full of high yielding trees. It might also be found that the largest seeds would give the biggest plants. It seems to us worth while experimenting in this matter of seed selection.

III. Manufacture of Gur.

In the manufacture of gur there is room for much improvement. The whole process is an extremely dirty one. The earthen pans are never cleaned from one end of the season to the other. The consequence is that burnt sugar and much dirt and many ferments collect in the pans. A good proportion of the dark colour of date gur must be due to the burnt sugar collecting in the pans. Mr. B. C. Basu carried out some experiments on the use of iron pans in Jessore in 1892-4 and states[1] that he prepared jaggery of exceedingly fine quality which was capable of producing almost pure white sugar when treated by the centrifugal. We here append analyses of a sample of gur and of rab prepared in iron pans by Mr. Chatterjee in Central India. These samples were much lighter in colour than the gur prepared in Jessore in earthen pans and it will be seen they are of good quality.

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[1] Reports of Department of Land Records and Agric., Bengal, 1892-3, pp. 32-33 & 1893-4, pp. 16-17.

	Sucrose.	Reducing sugar.
Gur	81·24	2·37
Rab	69·70	3·72

Owing to the fact that the juice is practically neutral in reaction very little loss of sucrose should occur during the boiling process. It certainly seems to the writer that something ought to be done to import iron pans into the district. The real difficulty in introducing them lies in the fact that often such small quantities of juice are boiled by one man that it would not pay him to purchase an iron pan. Something however might be done in the nature of co-operation among the people so that several men could combine their work and purchase a pan between them. It is probable that the larger scale on which the operations could be then carried out would result in a saving of fuel.

IV. Methods of Refining.

The present native method of refining by means of water weed is an exceedingly slow process, but it has the advantage that very little outlay is required. If, however, centrifugals could be introduced the process would be a much quicker one and the turnover would be much greater. The quality of sugar produced would also be much better. Mr. B. C. Basu[1] carried out experiments in Jessore in 1893-4 with the centrifugal and obtained good results when he used good quality jaggery. His remarks shew that his experiments aroused great interest. He concluded that if centrifugals come into use, the cultivators would soon produce a better quality jaggery.

It would further be a good plan if the people could be induced to strain their juice through cloth before boiling it down. Numberless pieces of wood, bark and other impurities are to be found in the juice and on boiling these all tend to darken the syrup.

In the meantime the people should be persuaded to clean out daily the earthen boiling pans which are at present in use. They could be scrubbed clean with water as is done daily in those parts of Jessore district where an eating gur is made from sugarcane.

[1] Loc. cit.

The cultivator says he does not clean his pans because after putting water in them they are liable to crack on the fire. Yet in the case of boiling the sugarcane juice, when earthen pans are used and cleaned daily with water, the pans seldom crack.

V. Method of Tapping.

The main drawback to the use of date juice for sugar manufacture is its high glucose ratio. The writer has shewn however that the juice as it exudes from a freshly cut surface of the tree contains only sucrose and that the reducing sugars are formed subsequently as a result of fermentation. If this subsequent fermentation could be stopped, the industry should have a great future. It occurred to us that if the trees were tapped by drilling holes into them with an auger then a much higher quality of juice would be obtained for there would not be such a large cut surface exposed to the air. It was found however that the flow of juice from holes drilled into the tree was practically negligible. Indeed, in the native process of tapping it will be remembered that the sap yielding surface is not cut into at once in the beginning of the season. If this is done very small yields of juice only are obtained. The bark is first removed and the delicate underlying tissues are exposed for some time. The copious flow of juice is apparently due to excitation of the tissues due to the wound.

It seemed to us desirable to test the effect of a simple antiseptic in preserving the quality of the juice. Formalin was chosen for this as it is a good disinfectant, easily obtainable and cheap. The experiments on page 342 have shewn how effective the substance is, in preserving date juice. In the field it is impossible to plan experiments to shew exactly how great is its effect. The real difficulty is to find two sets of trees which are yielding exactly similar juice, so that one set may be treated with formalin and one remain untreated. Attempts were made to select groups of trees which would give juice of about the same composition. On several occasions 20 trees were selected and their yields measured. Attempts were made to collect these 20 trees into groups so that two groups might be obtain-

ed in which the composition of the juice was approximately the same. After several experiments it was decided that the variations in the quality of the juice between any two groups which might be so obtained was so large as to make it difficult to obtain a numerical value of the effect of formalin.

This effect was very obvious however. Most of the experiments were done by lightly washing the cut surface in the afternoon with a piece of cotton wool dipped in 10% formalin solution (commercial formalin diluted 4 times). The washing was done by the *gachi* himself in our presence. In almost every case the juice obtained from the formalined surface was quite clear and always much clearer than from untreated trees. Moreover in the morning the untreated surfaces always have a certain amount of yeast growth, whereas the surfaces treated with formalin were practically free from yeast. In order to make certain that the effect was due to the formalin and not to simply the cleaning of the surface, experiments were made in which the surface was washed in a similar way with water. This also lessened the yeast growth but not to such an extent as the formalin did, neither was the juice of such good quality. Perhaps the best proof of the efficacy of formalin was the testimony of the *gachi* himself. He was so pleased with its effect that he wished us to let him treat the whole of his garden in a similar way.

It has been shewn (page 340) that much of the inversion of the sucrose takes place after the juice has left the tree and while it is standing in the pot overnight. Hence it is reasonable to suppose that it would be worth while putting formalin in each pot overnight. In the cases where we tried this, very good juices were obtained. In one case in which one c.c. of 40% formalin was placed in the pot overnight and dokat juice collected, a juice was obtained containing in 100 c.c. 13 gms. of sucrose and 0·35 gm. of reducing sugar. This is a very good dokat juice indeed.

It would be worth while carrying out a more extended series of experiments on the effect of formalin. We should feel inclined to recommend washing the cut surface with formalin once a week

and the addition of a small quantity of formalin to the pots daily. Of course one would have to calculate whether the cost of the formalin so used would be repaid by the extra amount of sugar recovered. About 3 c.c.[1] of 10% formalin[2] would be sufficient to wash each cut surface and one c.c. of 10% formalin[2] might be tried in each pot. Taking 100 trees the amount of formalin per season would then work out as follows :—

3 c.c. per week per tree for 13 weeks equals		3,900 c.c.
1 c.c. per pot for every juice-yielding night, say 44, equals ..		4,400 c.c.
	TOTAL	8,300 c.c. 10% formalin.
	equals ..	2,100 c.c. roughly 40% formalin.
	equals ..	4·6lbs. formalin roughly

4·6lbs. at 12 As. per lb. (market price in bulk in India) is equal to 55 annas per 100 trees or about half an anna per tree. Half an anna per tree is but a very small expenditure.

A 5% increase in yield of sugar per tree would account for it for taking the average yield of gur per tree as 22½lbs. A 5% increase would be about 1lb. of gur.

Any increase in yield over 5% resulting from the treatment would therefore be profit and from our preliminary experiments it seemed that by formalin treatment a very appreciable increase in yield of sugar per tree might be obtained.

VI. SYSTEM OF COLLECTION OF JUICE.

It has been shewn that much of the sugar is lost by inversion during the night after the juice has flowed from the tree. The dirty state of the earthenware collecting pots must have a good deal to do with the large amount of inversion. Earthenware pots in any case would be difficult to clean, and as a matter of fact the pots are never cleaned from one end of the season to the other, the only treatment they receive being that of smoking. It seems to us that it would be much better if cheap metal pails could be substituted for

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[1] 28 c.c. equals roughly 1 oz.

[2] Dr. Butler, Imperial Mycologist, thinks that probably 1% formalin would be equally effective. If so, then the cost of treating the trees would be very small indeed.

the earthen pots. It would be preferable for the pails to have loosely fitting lids. Such pails could easily be cleaned. We had occasion in some of our experiments to collect juice in an enamelled vessel. The juice so obtained was always of much better quality than that collected in earthenware pots and this can only be ascribed to the more cleanly nature of the enamelled pot.

VII. Carriage of Gur to Refineries.

All the gur is taken to the refineries in the native earthen pots. It has been explained on page 359 that in order to get the gur out of the pots the refiners have to break them. The result is that the sugar always contains a certain amount of small pieces of earthenware. Where European refineries purchase the gur this is a distinct drawback as the pieces of earthenware cut the filter bags which are used in the refinery and thus are a source of great trouble. Again the earthen pots filled with gur when loaded on to a cart are easily broken and it is a common occurrence for a cart thus loaded to upset down a bund, with consequent large loss of sugar. If barrels or metal drums could be introduced in place of these earthen pots these disadvantages would be done away with.

VIII. We have finally to throw out a suggestion which seems to us worthy of experiment. Careful enquiries in the district, conducted chiefly by Mr. H. D. Chatterjee, seem to make it clear that the tappers would sell their juice at 4 to 4½ annas per maund, rather than take the trouble to boil it into gur. It seems possible that an enterprising man might find it worth his while to set up in any given centre and buy juice from the surrounding tappers. He might fit up say a Hadi process plant capable of dealing with 60 to 100 maunds of juice per day and prepare gur. This gur should be of much better quality than the ordinary gur of the district and should fetch a much higher price. In addition a centrifugal might be fitted up for the purpose of producing white sugar.

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